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NEUROPHYSIOLOGICAL AND BEHAVIORAL DYNAMICS OF EMOTION IN MOTHERS OF YOUNG CHILDREN

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ABSTRACT

Parenting infants and toddlers is inherently intertwined with emotion. Conceptualizing emotion as a complex, contextually driven process consisting of appraisals, action readiness, and regulation, this study investigated how mothers of young children experience and regulate their own emotions in the context of challenging parenting situations. The study drew upon the benefits of two complementary methodologies: electroencephalogram (EEG) provided an index of mothers' action readiness at the neurophysiological level (*N* = 101), while ecological momentary assessment (EMA) captured emotions at the phenomenological level (*n* = 55). Relations among mothers' self-reported emotions, action readiness, and regulation in day-to-day life (measured by EMA) were generally in line with functional emotion theory; however, some exceptions provided support for the notion that emotion must be studied *in context.* Mothers' emotion regulation in the face of naturally-arising challenging situations with their 14- to 24-month-olds (measured by EMA) was associated with their experiences of positive and negative emotions in the moment of the challenge and with their general, more "trait-like" emotional states. Activity in the frontal cortex in response to videos of infants in distress at 6-8 months (measured by EEG) was associated with emotion regulation during evocative parenting situations when children were in the second year of life (measured by EMA). Taken together, the findings begin to paint a picture of how parents experience and regulate emotions in the context of a relationship in which they are responsible for the physical and emotional well-being of their children as well as of themselves. Further research in this area has the potential to inform interventions for at-risk families.

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Chapter 1. INTRODUCTION

Emotion is thought to be inherent to parenting in at least two ways: (1) the very act of parenting is emotionally evocative, and (2) parents' emotions play a major role in children's adaptive development. Although an understanding of both of these ideas is critical to the well-being of children and families, they have received unbalanced empirical attention. The impact of parent emotion on child development has been rigorously studied in multiple areas of the literature, such as in research on emotion socialization (e.g., Eisenberg, Cumberland, & Spinrad, 1998), including the socialization of coping strategies (Eisenberg, Fabes, & Murphy, 1996), and the impact of parental psychopathology on child adjustment (particularly maternal depression, e.g., Campbell et al., 2004; Cummings, Keller & Davies, 2005; Goodman & Gotlib, 1999).

Much less work has examined how adults experience and regulate their emotions in the parenting context. Specifically, we know little about the various combinations of emotions that parents experience when caring for their children, the time course of those emotions, how they relate to coping, and how they operate both in- and out-side of parents' awareness. This lack of knowledge is at odds with clinical practice for both adult and child mental health problems, and gaps are present in treatments for both. For example, well-designed treatment outcome studies for postpartum depression (i.e., RCTs, studies that employ large sample sizes and observations of parenting behavior) tend to show positive effects for maternal symptoms (Cooper, Murray, Wilson, & Romaniuk, 2003; Forman et al., 2007; O'Hara, Stuart, Gorman, & Wenzel, 2000) or child and parenting outcomes (Horowitz et al., 2001; Jung, Short, Letourneau, & Andrews, 2007), but not both. For children, although manualized, empirically supported treatments for disruptive behavior disorders emphasize parenting skills training (e.g., Eyberg & Bussing, 2010; Hood & Eyberg, 2003; Webster-Stratton, Reid, & Hammond, 2005), they do not include a targeted component that helps parents modify their *own* emotions in stressful parenting situations. This is at odds with the theoretical and empirical work showing that cycles of emotional dysregulation of both children and parents is a major etiological and maintaining factor for child disruptive behavior disorders (Patterson, 1982; Burke, Loeber, & Birmaher, 2002). Thus, the lack of understanding of the parental emotion experience (both conscious, e.g., subjective feelings, and unconscious, e.g., immediate physiological responses) reflects a major gap in the literature that limits our ability to effectively intervene in child and adult mental health problems.

This introduction will begin with a presentation of the theoretical perspective that organized the research questions, followed by a framework for how emotion processes relate to parenting. The challenges of studying emotion in adults will then be considered along with methodological approaches that can address many of them.

Functional Theories of Emotion

Functional theories conceptualize emotion as a multifaceted system that organizes and supports action in the service of individuals' goals for well-being (Arnold, 1960; Barrett & Campos, 1987; Frijda, 1986). Goals for well-being vary widely, ranging from instinctual (e.g., goal to survive), immediate, and unconscious, to conscious, complex, and long-term. An emotion is a response to a change in the environment (stimulus) that is perceived to have an impact on those goals. Emotional experience consists of attempts to initiate, alter, maintain, or terminate specific relations with the stimulus (Campos, Mumme, Kermoian, & Campos, 1994); thus, emotion reflects a *transaction* between an individual and the environment. As a result, an emotion does not reflect a single, static event, but rather indicates the onset of a multicomponent *process* (Barrett & Campos, 1987; Davidson, 1998) that includes appraisal, behavioral action readiness, and in some views, regulation. These components are indissociable from one another, operate at physiological and behavioral levels, and occur both in *and* outside of awareness (Barrett & Campos, 1987; Campos et al., 1994).

Appraisal and action readiness. Appraisal refers to an individual's perception of the *significance* of a situation in relation to goals for well-being (Barrett & Campos, 1987; Frijda, 1986, 1988); it is through appraisal that personally-relevant meaning is assigned to changes that occur in the environment or internally. Appraisals may operate at an automatic or unconscious level (e.g., in the fight/flight response), but may involve complex or abstract cognitive processing. Action readiness refers to organismic preparedness to act in a particular manner, specifically, to withdraw/disengage from vs. approach/engage with the environment. Although the relations between appraisal and action readiness are debated (e.g., whether they are temporally linked or coterminous), the two together are the defining features of emotion (Arnold, 1960; Barrett & Campos, 1987; Frijda, 1986, 1988; Frijda, Kuipers & ter Schure, 1989). For example, dissimilarities in appraisal and action readiness are critical in differentiating anger and sadness from one another: an angry person appraises that a goal for well-being is blocked and is prepared to engage with her environment to regain the goal, and a sad person appraises that a goal for well-being must be relinquished and is prepared to give up acting on the goal. Each discrete emotion, positive and negative, is thought to have a specific appraisal-action readiness profile (Barrett & Campos, 1987).

If, from a functional perspective, emotion organizes behavior, then it is important to understand the physiological substrates underlying an organism's readiness to act. Previous research shows that changes in the autonomic nervous system, endocrine system, immune system, muscular system, and the brain (Bradley & Lang, 2000; Ekman, Levenson, & Friesen, 1983; Lang, 1995; LeDoux, 1994; Levenson, Ekman, & Wallace, 1990) are associated with emotional experience with implications for behavior. For example, contraction of facial muscles causes the eyes to widen during surprise, which may function to increase visual alertness to novel events so that their threat potential can be evaluated, providing the opportunity to withdraw by fleeing if danger is detected (Ekman & Friesen, 2003). Thus, physiological changes can be seen to provide the logistic support for action from emotional experience (Bradley & Lang, 2000; Ekman, 1992; Frijda, 1988).

Regulation. In addition to appraisal and action readiness, functional emotion theorists consider regulation to be an inherent part of the emotion process (e.g. Campos et al., 1994; Campos, Frankel & Camras, 2004; Davidson, 1998; Frijda, 1986; Gross, 1998). From a functional perspective, emotions are both regulatory and regulated (Cole, Michel, & Teti, 1994; Gross & Thompson, 2007). If emotion organizes action, then it exerts regulatory processes on behavior and underlying physiological and cognitive processes. For example, positive emotion influences bodily functions like digestion and blood flow (Lefcourt, 2005) and broadens individuals' thought-action repertoire, including attention and cognition (Fredrickson, 1998). Emotions themselves are also regulated; in this sense, emotion regulation has been defined as systems of psychological and physiological processes that monitor, evaluate, and modulate emotional *reactions* in the service of individuals' goals (Thompson, 1994). It has been increasingly recognized that, whether consciously or not, regulatory processes are almost always recruited when an emotion occurs (Campos et al., 2004; Davidson, 1998). As the relationship between an individual's situation and goals changes, adjustments occur in the emotion itself, in its temporal and intensive qualities, and in related behavior. In other words, if emotions consist of person-environment transactions that seek to maintain or change relations with the environment in the service of goals (Barrett & Campos, 1987; Campos, 1994), it is logical that emotions themselves would fluctuate according to ongoing progress (or lack thereof) made toward the goal.

The regulation of emotions has been studied in many ways, such as by observing individuals' expressed emotions and behaviors in evocative situations (e.g., Cole, Tan, Hall, Zhang, & Crnic, 2011), by asking individuals about strategies they use to manage their emotions in specific situations (e.g., Wadsworth, Raviv, Compas, & Connor-Smith, 2005), and by recording physiological processes indicative of regulation (e.g., vagal tone; Moore, 2009). In line with functional emotion theory, emotion regulation may be conceptualized as the maintenance or modulation of action readiness and appraisal. For example, consider a mother in the midst of a naptime struggle with her 3-year-old. She might want to give in to her child in order to end the unpleasant situation, and leave the room to do something enjoyable; in many cases, however, the mother would regulate that *desire* to disengage (action readiness), and push forward with her goal to get her son to sleep. An example of regulation of appraisal in this situation could be changing her initial thought from, "I'm *never* going to get him to go to sleep," to, "He is tired, and he will eventually fall asleep." Regulation of both action readiness and appraisal may be assessed by asking individuals to report on their thoughts about and engagement or disengagement with a stressor (see Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001; Connor-Smith, Compas, Wadsworth, Thomsen, & Saltzman, 2000). Given its conceptual link with physiological substrates, action readiness may also be examined by mapping change in physiological indicators of motivation over time (see Killeen & Teti, 2012). Measuring action readiness at the physiological level allows researchers to capture the parts of this process that may occur outside of awareness.

This study conceptualized emotion as a multifaceted system consisting of components that support action in the service of an individual's goals for well-being, with appraisal serving to make meaning of the environment in relation to goals, physiological processes providing the logistic support for the transformation of action readiness into behavior, and regulation providing modulation of each of these components in order to be maximally effective in context.

Functional Theories of Emotion and Parenting

Emotion and its regulation must be understood in context (Barrett & Campos, 1987; Campos et al., 1994; Cole et al., 1994; Cole et al., 2004; Gross & Thompson, 2007), thus, the study of parental emotion must consider how various components of the emotion process are complexly intertwined with parenting. Dix (1991) laid out a model of the affective organization of parenting that applies functional theories of emotion directly to the parenting context. In parent-child interaction and other parenting-related situations (e.g., talking about the child with other adults, thinking about the child while alone, preparing activities for the child when he or she is not present), parents have goals that seek to promote the well-being of both themselves and their children. These goals can be immediate (e.g., "I need to help my baby stop crying now," or "I need to get the baby fed in the next 10 minutes so that I can get to work on time") or longer-term (e.g., "I want to get a baby-sitter for the kids this weekend so that I can have some adult time with my friends," or "I want my child to develop a sense of security"). Because parents strive to meet goals for their own and their children's well-being, parenting is inextricably linked to emotions.

Although the emotional *processes* underlying parenting are not well understood (Leerkes, Crockenberg, & Burrous, 2004; Teti & Cole, 2011), a growing body of research is progressively adding to knowledge in this area. There is empirical support for the affective organization of parenting, both in terms of the emotionally-evocative nature of parenting, and the impact of parent emotion on parent behavior. Observation of parent-child interactions in families with young children (e.g., Cole, LeDonne, & Tan, 2013; Cole, Teti & Zahn-Waxler, 2003; Huang, Teti, Caughy, Feldstein & Genevro, 2007; Martin, Clements, & Crnic, 2002) provide support for the emotionally-evocative nature of parenting by demonstrating relations between children's emotions and behaviors (both positive and negative) and maternal emotions. In addition, adult neural and physiological activation in response to child stimuli are thought to be indicative of emotion processing, both in experimental (e.g., hearing infant cries) and observational (e.g., parent-child interaction tasks) paradigms (Bugental et al., 1993; Martorell & Bugental, 2006; Lorberbaum et al., 2002; Strathearn, Li, Fonagy & Montague, 2008; Swain, Tasgin, Mayes, Feldman, Constable, & Leckman, 2008). Natural developmental transitions, such as the postpartum period (Graham, Lobel & DeLuca, 2002; Miller & Rukstalis, 1999; Swain, Lorberbaum, Kose, & Strathearn, 2007) and toddlerhood (LeDonne, Hajal, Cole, & Robinson, under review), are associated with increases in parent emotionality and sensitivity.

Empirical work also shows direct associations between parents' emotions and behaviors. Time-series analysis of mothers' and toddlers' emotions and behaviors during a challenging task showed that mothers' lax and harsh parenting was related to more immediate and intense maternal negative emotion, emotional lability, and greater dependence of mothers' emotions on their toddlers' emotions (Lorber & Slep, 2005). In a sample of 6-month-olds and their mothers, maternal negative emotions during parent-infant activities moderated mothers' abilities to achieve parenting goals; even when mothers' immediate goals were focused on their infants' emotions, they were unable to parent sensitively if experiencing their own negative emotions (Leerkes, Crockenberg, & Burrous, 2004). Similarly, a study of 4- to 6- year-olds showed that the frequency and intensity of children's negative emotion (observed at preschool) was associated with mothers' harsh responding if mothers also felt high personal distress in response to child challenging behaviors (Fabes, Leonard, Kupanoff, & Martin, 2001).

The literature on maternal depression further suggests that emotions engage and organize processes parents need to respond effectively to children (see Field, 2010, for a review, and Lovejoy et al., 2000, for a meta-analysis). Specifically, depressed mothers are more likely to be withdrawn, intrusive, and irritable with their infants (Cohn & Tronick, 1989), are less likely to parent supportively (Dix, Gershoff, Meunier, & Miller, 2004), to repair disruptions during parent-child interaction (Jameson, Gelfand, Kulcscar, & Teti, 1997), to breastfeed (Dennis & McQueen, 2007), and to sing, coo, or use "motherese" with their infants (Bettes, 1988). Because depression is characterized by increased negative emotion and diminished positive emotion, these findings suggests that atypical variations in emotion contributes to less optimal parenting.

Taken together, research in both typical (e.g., mothers' emotions and behavior during parent-child interactions) and atypical (e.g., caregiving behavior of depressed mothers) parent populations supports the notion that parents respond emotionally to child-related events, and that their emotion organizes (or, in some cases, disorganizes) behavioral responses toward children. More specifically, studies on both context-dependent negative emotion (e.g., Lorber & Slep, 2005; Leerkes, Crockenberg, & Burrous, 2004; Fabes et al., 2001) and maternal depression indicate that negative emotion inhibits effective parenting. Yet, we lack knowledge about how mothers may *regulate* that negative emotion to promote effective parenting in the face of stress (Teti & Cole, 2011). Given the potential for greater understanding in this area to add measurably to prevention and intervention programming for families, further empirical work on the nature of emotion as a multicomponent process in parenting is needed. Some researchers have begun to address this hurdle.

Appraisals in parenting. Previous research has suggested that mothers' negatively-biased appraisals of their children's behavior predict angry and irritable discipline strategies above and beyond the intensity of child misbehavior and age (Lorber, O'Leary & Kendziora, 2003). In addition, mothers who report lower levels of parenting self-efficacy (the degree to which adults appraise themselves as competent in the parenting role) or a lower sense of control over parenting challenges show more negative and less positive facial expressions of emotion in response to their own infants' happiness and distress (Hajal, Cole, Teti, & Moore, 2012), are more likely to display dysphoria (verbally and facially) during parent-child interactions (Bugental, Blue & Lewis, 1990), report more sadness and less adaptive coping during parenting challenges (Hajal, Cole, & Robinson, 2011), and show less optimal parenting behavior (Teti & Gelfand, 1991). This suggests that adults who appraise themselves as less competent in the face of circumstances that threaten their parenting-related goals experience emotions that heighten the chance of poorer quality parenting. Because many psychological disorders (e.g., depression, anxiety) are characterized partly by cognitive distortions (including overly negative appraisals), research in atypical parent populations also sheds light on the implications of extreme emotion for parenting appraisals. For example, depressed mothers have more negative appraisals of their children's behavior and competence not only in comparison to their non-depressed counterparts, but also in comparison to others (e.g., teachers, other parents, and independent, trained observers) rating the same children (see Dix & Meunier, 2009, for a review).

Action readiness in parenting. It is possible to infer the state of the *readiness of a person to act* using physiological measures. Studies that assess adults' physiological responses to child stimuli can add to our understanding of action readiness in the context of parenting. For example, affective neuroscience techniques (including EEG and functional magnetic resonance imaging) have shown that brain activity patterns associated with motivational approach and reward processing are often activated when mothers and fathers are exposed to auditory or visual stimuli of children (both their own and unfamiliar children; Bartels & Zeki, 2004; Hajal, Cole, Teti, & Moore, 2012; Killeen & Teti, 2012; Lorberbaum et al., 2002; Noriuchi, Kikuchi & Senoo, 2008; Strathearn, Li, Fonagy & Montague, 2008). These findings are consistent with the animal literature on the biology of mammalian maternal approach behavior (Swain, Lorberbaum, Kose, & Strathearn, 2007). Given similar physiological reactions whether child stimuli are positive (e.g., photos of smiling infants) or negative (e.g., audio of infant cries), the evidence suggests that in non-clinical samples of parents, child stimuli elicit physiological preparation to approach. This is consistent with the finding that primary motor areas of the brain are also activated in these studies (Strathearn, Li, Fonagy & Montague, 2008).

There also evidence of readiness to withdraw (to act to move away from a stimulus) in adults' neurophysiological responses to infant cries in both typical and atypical parent populations. For example, in addition to activation in reward circuitry in response to infant cries, parents showed withdrawal-related patterns in other areas of the brain (Lorberbaum et al., 2002). An individual’s capacity to respond to circumstances with multiple emotions (Cole, Hall, & Hajal, 2013), and the fact that parenting is a highly complex, emotion-laden activity (Teti & Cole, 2011), may explain the evidence of both approach and withdrawal readiness in response to infant distress. Given that infant cries are consistently rated as highly aversive, it is not surprising that both reward and threat circuitry is activated. Other work has shown that parents’ approach-related brain activation is less pronounced in response to negative child emotion (Strathearn et al., 2008), and that parents' withdrawal-related neural activity to infant distress is associated with greater self-reported and observed sadness (Hajal, Cole, Teti, & Moore, 2012) and emotionally available parenting (Killeen & Teti, 2012). Parents' action readiness may vary according to their own individual characteristics. For instance, approach-related brain activation was lower in postpartum mothers who had higher depressive symptoms, experienced more worry, and who had had a cesarean delivery (Swain et al., 2008). Taken together, this research suggests that in response to child signals of distress, parents undergo emotional processing at the neurophysiological level that indicates complex patterns of both approach and withdrawal readiness. This processing occurs within seconds of stimulus onset, suggesting and at least some of it may occur outside of awareness.

Empathy is an affective state that involves an emotional response, cognitive identification with another person, and regulation (Decety & Jackson, 2006). It is especially relevant to parenting because parents' goals are related not only to their own well-being, but also to the well-being of their children. Thus, it is necessary to consider patterns of action readiness in the context of empathic responding. Research has shown that the patterns of brain activity related to empathy are similar to those that (in other work) have been associated with approach readiness (Moriguchi et al., 2007), withdrawal readiness (Killeen & Teti, 2012) or a combination of the two (Light, Coan, Zahn-Waxler, Frye, Goldsmith & Davidson, 2009). The multifaceted nature of the action readiness findings associated with empathy is consistent with the idea that empathy consists of sharing of feelings with another person (Decety & Jackson, 2006) as well as a motivation to help the person for whom empathy is felt (see Batson, 1998; Eisenberg & Miller, 1987), and suggests complex patterns of action readiness in parenting.

Regulation in parenting. Of all of the components of emotion, parents' emotion regulation has received the least attention. The few studies that have considered it have examined either emotion regulation strategies like emotional suppression or cognitive reappraisal (e.g., as conceptualized by Compas et al., 2000; Gratz & Roemer, 2004; Gross & Thompson, 2007), or physiological regulation. Responding to hypothetical vignettes, mothers reported being more likely to suppress their own negative emotions if child emotions were not hostile (Martini, Root, & Jenkins, 2004). Mothers also report that their increased suppression and reappraisal during discipline encounters, assessed with questionnaires, were related to less angry and irritable parenting (Lorber, 2011). An ecological momentary assessment study (repeated assessments that take place in participants' natural environments) showed that mothers' daily positive emotion and positive emotion stability predicted their questionnaire-reports of coping strategy use during challenging situations with their children (Hajal, Cole & Robinson, 2011), and that less sadness and a higher sense of control during daily parenting situations predicted the use of strategies known to be more adaptive in daily life (Hajal, Cole & Robinson, 2011). Finally, another study found that exposure to angry stimuli influenced mothers' physiological regulation during a parent-infant interaction (Moore, 2009).

Ultimately, initial evidence shows support for the theory that parents' emotions and emotion regulation are the result of the complex interplay between their goals, beliefs, physiology, and context, all of which play a crucial role in organizing behavior in the parenting context. However, more work is needed to understand how the multiple components of the emotion process, including emotion regulation, work together in the real-life child-rearing context to support or undermine parenting behavior. The present study aimed to further the field's understanding of the nature of parent emotion regulation in the context of challenging parenting situations. Drawing directly on the functional perspective of emotion as applied to parenting, it conceptualized emotion regulation as the maintenance or modulation of action readiness and appraisal. Given that emotion and its regulation occurs across the spectrum of unconscious, automatic to conscious and deliberate processes (Frijda, 1986; Gross & Thompson, 2007), this study measured action readiness at the neurological and behavioral level, as well as mothers' reports of their emotional processes in daily life.

Empirical Study of Adult Emotion: Challenges and Methodological Solutions

There is a clear need for empirical investigation of the emotion process in the context of parenting. However, there are also major challenges to studying a dynamic, largely unobservable psychological process in adults, who are often able to regulate the observable expressions of their emotions. First it is important to consider the multiple components of the emotion process (i.e., appraisal, action readiness, regulation) and how they each may vary in intensity and time-course (Davidson, 1998; Thompson, 1994). Second, given that emotion occurs in multiple systems (i.e., at behavioral and physiological levels; Gross, 1998), ideally, emotion research should use multimodal measurement. Third, emotions occur across multiple time-scales, from extremely fast and fleeting to protracted over hours, days, or weeks. Thus, measures with very fast time resolution (Davidson, 1992), as well as those that assess emotion longitudinally (Ebner-Priemer & Trull, 2009) are crucial to a comprehensive understanding of emotional processes. Fourth, adults are typically adept at masking their emotions (Saarni, 1993; Saarni & Crowley, 1990), so steps must be taken to ensure that assessment results in accurate data. Finally, emotions and emotion regulation are contextually driven (Cole et al., 1994; Cole et al., 2004; Compas et al., 2001), and so should be studied in as ecologically valid a manner as possible.

No single approach, behavioral or physiological, is sufficient to address all of these challenges. Thus, this study integrated two methods whose strengths complement one another: a neurophysiological method (EEG) and an ecologically-valid behavioral method (ecological momentary assessment; EMA). Specifically, EEG captured mothers' action readiness and regulation at the neurophysiological level, while EMA was used to obtain ecologically valid self-reports of mothers' current and very recent emotions, action readiness, and emotion regulation (including reports of coping strategies, stress responses, and regulation of action readiness).

Using EEG to measure parents' action readiness at the neurophysiological level. EEG provides information about an individual's second-by-second brain electrical activity. The time series data provided by EEG has been used in many ways, and most often in the emotion literature to measure frontal cortical hemispheric asymmetry (e.g., greater right- versus left-sided activity). Frontal asymmetry can be interpreted as reflecting the individual's immediate readiness to orient toward the environment by approaching or withdrawing. Thus, it has the ability to capture action readiness, which occurs extremely quickly and possibly outside of awareness, at the physiological level. Greater relative left frontal activity (left asymmetry) is related to approach readiness while greater relative right frontal activity (right asymmetry) is related to withdrawal (Coan & Allen, 2004; Davidson, 1998). Action readiness as indexed by frontal asymmetry is related to self-reported behavioral inhibition and activation (Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997) and observed behavior (Harmon-Jones, Sigelman, Bohlig, Harmon-Jones, 2003; Harmon-Jones, 2007). Variation in EEG-measured action readiness is related to questionnaire reports of dispositional emotion and to observed and self-reported emotion in response to experimental paradigms as would be expected given the action readiness component of specific discrete emotions. Specifically, left asymmetry is associated with approach-related emotions like anger (Harmon-Jones et al., 2003), joy (Davidson & Fox, 1982; Light, Coan, Frye, Goldsmith, & Davidson, 2009), and anxious apprehension (Mathersul, Williams, Hopkinson, & Kemp, 2008) and right asymmetry with withdrawal-related emotions like sadness (Davidson & Fox, 1989; Tomarken, Davidson, Wheeler, & Doss, 1992), disgust (Davidson, Ekman, Saron, Senulis, Friesen, 1990), fear (Mathersul et al., 2008), and low-level joy (Light et al., 2009). Greater right and reduced left asymmetry seem to be vulnerability markers for psychopathology: resting right asymmetry is associated with phobias (Davidson, Marshall, Tomarken, & Henriques, 2000), depression (Putnam & McSweeney, 2008), and restrained eating (Silva, Pizzagalli, Larson, Jackson, & Davidson, 2002), all of which include withdrawal as a hallmark symptom. Heightened right asymmetry is also seen in at-risk populations, such as those with lifetime (Henriques & Davidson, 1990), and family histories (Dawson, Panagiotides, Klinger, & Spieker, 1997) of depression.

Although most EEG studies aggregate asymmetry scores over periods of time, it is possible to examine their second-by-second data streams in a time-series fashion. As noted, it has been argued that the temporal course of responses associated with emotion index the parameters of regulatory processes (Davidson, 1998; Thompson, 1994). Specifically, the latency, duration, rise time, and recovery of emotional responses indicate not only the reactivity of the individual but also the nature of recovery from an emotion. Empirical work demonstrates that individual differences in these time course variables (which have, at this point, been assessed mostly with self-report and non-EEG physiological measures) are associated with personality (Blackford, Avery, Shelton, & Zald, 2009; Fredrickson et al., 2000; Hemenover, 2003; Suls, Green, & Hillis, 1998), psychopathology (Kuppens, Allen, & Sheeber, 2010; Larson et al., 2006; Larson, Nitschke, & Davidson, 2007) and other risk factors (Larson, Taubitz, & Robinson, 2010;

Tong et al., 2009) in expected directions as far as emotion regulation. For example, one study found that depressed individuals who were particularly high in anhedonia (inability to experience positive emotion) showed an unusually fast return to typical startle response after being exposed to pleasant stimuli. This suggests that these individuals have difficulty sustaining positive emotion (Larson et al., 2007), which may be interpreted as an emotion regulation difficulty in anhedonia.

Given the promise of research examining temporal aspects of emotion along with EEG's potential to provide rich time-series data, its ability to capture action readiness at the neurophysiological level, and the hypothesis that one major role of the frontal cortex in emotion involves regulation of the *time course* of responding (Davidson, 2004), it is surprising that very few EEG studies have examined data in a time series fashion. Although a handful of studies (Larson et al., 2006; Blackford et al., 2009; Killeen & Teti, 2012; Light et al., 2009; Todd, Lewis, Meusel, & Zelazo, 2008) have used brain imaging techniques to model affective chronometry, most have used methods that lack some of EEG's benefits. For example, time series analysis of EEG data could add information beyond that which could be obtained by examining event-related potentials because it allows study of multiple aspects of the time course of neural responding (e.g., duration, recovery) as it unfolds beyond a few seconds. In addition, EEG is preferable over fMRI for this purpose, because it has a faster time resolution (Harmon-Jones, 2007). Further, there is a substantial literature linking motivational processes to EEG asymmetry, and less to measurements obtained from fMRI or event-related potentials.

This study drew on the novel work of two laboratories that have capitalized on the rich time-series data provided by EEG to understand emotional processes, particularly related to empathy. In a study of mothers' EEG asymmetry and self-reported emotions, Killeen and Teti

(2012) showed that mothers who experienced a *shift* toward right asymmetry at the onset of a 10-second video of their infant in distress reported feeling more negative emotions while watching the video, and also showed more emotionally available parenting during a separate observational task. The authors interpreted these results as indicative of an empathic response in which mothers shared their infants' distress. Consistent with these results, another study examined associations between children's empathy and their patterns of EEG asymmetry during a longer (but separate) pleasurable task (Light et al., 2009). Children high in empathic concern showed patterns of EEG asymmetry characterized by an initial right asymmetry that later shifted to left asymmetry. The authors noted that this changing EEG asymmetry profile reflects the capacity to shift between states as needed in empathy-eliciting situations (Light et al., 2009). Indeed, empathy reactions involve feeling not only the negative emotions of the other, but also a sense of goodwill and a motivation to help (Batson, 1998; Eisenberg & Miller, 1987). Together, the findings of Killeen and Teti (2012), Light and colleagues (Light et al., 2009), and of fMRI studies indicating both withdrawal- and approach-related patterns of brain activity in empathic processing (e.g., Moriguchi et al., 2004) and parenting (Lorberbaum et al., 2002; Strathearn et al., 2008), suggest that empathic responses to others' distress may follow a dynamic course of physiological processing in which right asymmetry reflects identification with another's distress, while left asymmetry reflects an approach-orientation that is conducive to helping behavior. By integrating EEG and EMA methods, this study tested the hypothesis that mothers who show this dynamic pattern of action readiness at the neurophysiological level (measured by EEG) in reaction to infant distress would show greater use of adaptive emotion regulation in daily parenting challenges in their natural environments.

Using ecological momentary assessment (EMA) to capture appraisals, action readiness, and regulation. Several issues in the study of adult emotion, including (1) consideration of emotion as a multicomponent process, (2) its temporal nature and (3), the importance of considering emotion *in context*, may all be addressed by measurement of emotional processes with ecological momentary assessment (EMA), a dynamic and highly ecologically valid methodological approach. EMA is not in and of itself a single method, but rather, it has been characterized as a collection of methods that share 3 core characteristics: (1) *repeated assessments* of (2) *current or very recent* states, (3) in the context of each individual participant's *natural environment* (Ebner-Priemer & Trull, 2009; Shiffman, Stone & Hufford, 2008; Wenze & Miller, 2010). As a result of the naturalistic setting of data collection, EMA is ideal for assessing phenomena that, like parental emotion, are driven by context (Myin-Germeys et al., 2009; Wenze & Miller, 2010). EMA's high ecological validity is due not only to its contextual validity, but also to temporal validity in that its repeated sampling provides information on how states (including emotions) occur over time. Furthermore, in terms of both contextual and temporal aspects of ecological validity, EMA is preferable to laboratory observations because it is more likely to provide contexts that elicit a full range of behavior, it does not rely on situations that may seem artificially contrived, and it allows states to be examined beyond a relatively short time frame (Moskowitz, Russell, Sadikaj, & Sutton, 2009; Shiffman, 2009). EMA also has increased reliability due to repeated assessments and it circumvents memory biases (Trull & Ebner-Priemer, 2009; Moskowitz et al., 2009; Myin-Germeys et al., 2009; Wenze & Miller, 2010), both of which are problematic in studies that utilize single, self-report questionnaire measures of emotional processes.

EMA approaches have been used to study a broad array of topics pertaining to human adjustment and maladjustment. A substantial subset of this work has focused on emotion, while a much smaller portion has examined parenting-related constructs. EMA work has contributed to these areas in a variety of ways. It has elucidated dynamic characteristics of emotion processes, such as affective instability (Jahng, Wood, & Trull, 2008; Trull et al., 2008), by using multiple data points to create time-course variables. EMA data has also been used to uncover antecedents and consequences of constructs of interest by employing time-series analyses to relate emotions, states or behaviors at one point in time to those at other times of the day (Wenze & Miller, 2010). Many of these studies have examined the impact of certain types of events on later emotions, symptoms, or behaviors. For example, time-sensitive analytic approaches of EMA data have identified antecedents of manic and depressive episodes in bipolar patients (Bauer et al., 2006), marital (Almeida, Wethington, & Chandler, 1999) and work-related (Gassman-Pines, 2011a, 2011b; Matjasko & Feldman, 2006; Repetti & Wood, 1997) predictors of parenting behavior and later mood, and differences in the temporal impact of negative daily events on mood in depressed and nondepressed adults (Peeters et al., 2003). Other studies have showed the regulatory impact of emotion on behaviors, such as recovering smokers' stress-related negative affect in the hours before relapsing (Shiffman & Waters, 2004).

Fewer studies, however, have used EMA to understand multiple components of the emotion process. One study examined appraisals, mood, and coping in individuals with chronic pain, and found that higher momentary ratings of pain throughout the day were associated with higher nighttime reports of less perceived control and efficacy, greater catastrophizing, and lower mood (Tennen, Affleck, & Zautra, 2006). A study focusing on emotion regulation examined adolescents' self-reports of emotion and use of specific emotion regulation strategies (e.g.

cognitive reappraisal, distraction, avoidance) throughout the day, and showed that certain strategies were related to improvement versus maintenance of negative emotion (Silk, Steinberg, & Morris, 2003). Due to the present study's interest in understanding the interplay of multiple components of emotion, it collected multiple measurements of mothers' emotions, action readiness, and regulation in naturally arising parenting situations.

Another benefit of EMA is its ability to identify predictors of emotion, behavior, and regulation at multiple levels of analysis. It is well documented that parenting is influenced by both enduring individual characteristics of the parent, child, and family environment (Belsky, 1984) as well as situational factors (Ciciolla, Crnic & West, 2013; Miller, Shim, & Holden, 1998). The literature cited above on negative emotion and parenting provides a good example: maternal negative emotions are related to less effective parenting behavior both when measured at the state-level, i.e., within a single parent-child interaction (Leerkes, Crockenberg, & Burrous, 2004; Lorber & Slep, 2005), and when considering more "trait-like" negative emotional states such as depression (Lovejoy et al., 2000). Because EMA can provide multiple assessments of state-related emotions, behavior, and regulation, it enables researchers to examine the combined effect of state- and trait-related variables on outcomes. Specifically, in addition to examining the relations between emotion and behavior in a given instance, an individual's more typical or "trait-like" way of responding can be calculated based on their intraindividual average response across assessments (Fleeson, 2001; Ram et al., 2013; Ram & Gerstorf, 2009). Using appropriate statistical techniques, the impact of this intraindividual average way of responding on emotion or behavior in a particular situation can be tested. For example, Maher and colleagues (Maher et al., 2013) showed that daily life satisfaction was associated with daily physical exercise, but *not* with general tendency to exercise. Thus, use of EMA allows researchers to disentangle whether parents' ability to regulate emotions during day-to-day parenting situations is predicted more strongly by situation-specific emotions or by more enduring mood states.

Integration of EMA and EEG approaches. The present study aimed to understand emotional processes in mothers by integrating EMA and EEG methods, which capture markedly different timescales that are both relevant to parenting. EEG indexed the time course of neural activity, capturing immediate, micro-momentary changes in physiology associated with action readiness and regulation, while EMA provided information about parents' subjective experiences of emotion over the course of 6 days in their natural environments. In concert, these two methods permitted assessment of emotion as an ongoing, contextually driven process that occurs at multiple levels of analysis.

To date, only 3 studies (none of parents) have integrated EMA with physiological data obtained in a different setting. Silk and colleagues (Silk et al., 2007) showed that children's pupillary dilation in response to an emotion valence identification task in the laboratory was related to positive and negative emotion in daily life. Forbes and colleagues (Forbes et al., 2009) showed that adolescents' reward processing as measured via fMRI was related to day-to-day positive emotions. Finally, particularly relevant to the present study, Putnam and McSweeney (2008) studied relations between adults' resting prefrontal cortical asymmetry in the laboratory and depressive symptoms (including appraisals and stress responses) in a small sample (N = 13). They showed that less overall prefrontal activity predicted daily rumination, while less left asymmetry was related to lower daily self-esteem. Despite the fact that none of these studies used analytic approaches that took advantage of the temporal richness of the EMA data, they represent important first steps in integrating physiological and EMA methods. They add to the literature on both EMA and their respective physiological methods because they show that distinct biological processes associated with emotion as measured in the laboratory *are* in fact related to individuals' naturalistic, real-world experiences. This has major implications for clinical practice, as it shows external validity for physiological measures that are typically obtained in environments that are very different from the contexts in which we are actually interested in them.

The Present Study

This study integrated EEG and EMA methods to enhance the field's understanding of emotional processes in parents of young children, with the ultimate goal of adding to a knowledge base that can inform interventions for at-risk families. In conceptualizing emotion as a contextually drive, multicomponent process, the study used both physiological and behavioral methods to examine mothers' appraisals, action readiness, and regulation in response to challenging, parenting-related situations.

A neurophysiological measure (EEG) was used to chart mothers' action readiness at the physiological level in response to infant distress. Mothers' subjective experiences of action readiness and appraisals were measured by EMA self-reports of their happiness, confidence, contentment, pleasure, sadness, anger, and worry at multiple moments over the course of 6 days. Each discrete emotion was examined in terms of its appraisal/action readiness profile (e.g., anger/irritation is characterized by appraisal of a situation as significant, of the goal as blocked, and of approach action readiness). Action readiness was further assessed by mothers' ratings of the extent to which they wanted to engage in (approach) or disengage from (withdraw) various situations.

Mothers' emotion regulation in response to parenting-related challenges was examined at both behavioral and physiological levels. Cole, Martin, and Dennis (2004) addressed hurdles in studying emotion regulation in a scientifically rigorous manner, and outlined 4 ways in which scientists can design their studies to appropriately infer emotion regulation. One recommendation was to consider *temporal* relations between the occurrence of an emotion and regulatory phenomena. In order for a specific behavior (e.g., averting gaze) to be considered regulatory, it must occur after the initiation of an emotion that can be regulated. Thus, in the present study, emotion regulation was operationalized as states (e.g., physiological, behavioral) that occurred *in response to* negative emotion. At the neurophysiological level, an innovative, time-series analytic approach was used with the EEG data in order to examine how micro-momentary *changes* in action readiness (e.g., shift from right asymmetry to left asymmetry, indicating a shift from withdrawal to approach readiness) might be associated with its regulation. As part of the EMA protocol, mothers were asked to rate how much they felt each emotion in a given situation. If mothers expressed negative emotion, they were then asked the following questions to assess regulation: (1) how much they wanted to engage in and disengage from the situation (desired behavior, or, action readiness) (2) how much they actually were engaged in and disengaged from the situation (actual behavior), and (3) what they thought and did during each situation.

Mothers' phenomenological emotion regulation was indexed in two ways. First, mothers' self-reports of action readiness and actual behaviors were considered in concert; presumably, if mothers expressed a *desire* to disengage from a challenging situation, but reported that they did not *actually* disengage, then they successfully regulated readiness to disengage. Mothers may also need to regulate the desire to engage in parenting situations. For example, regulation of the desire to engage when angry could be protective against harsh discipline, or could be employed to promote child development; for example, a mother might feel compelled to comfort her toddler when upset, but may (i.e., a mother might hold back on her desire to comfort if she is trying to foster the child's ability to self-soothe). To assess subjective regulation in a second way, mothers' open-ended responses of their thoughts and behaviors during evocative parenting situations were later classified as adaptive coping strategies, like cognitive restructuring and problem solving, or maladaptive stress responses, like avoidance and rumination (Compas et al., 2001; Connor-Smith et al., 2000). Coping strategies are conceptualized to involve engagement with the stressor in an effort to modify the situation or emotion (primary control engagement coping), or to adjust one's thoughts in order to adapt to a situation that cannot be changed (secondary control engagement coping). Primary control engagement strategies may be viewed as serving to regulate action readiness, while secondary control engagement strategies regulate appraisals. Primary and secondary control engagement strategies are differentiated from maladaptive stress responses, which may involve engagement with the stressor (e.g., worrying, rumination) or disengagement (e.g., escape, wishful thinking), and have been previously linked to ineffective behavioral responses or emotion modulation (Connor-Smith et al., 2000; Connor-Smith & Compas, 2004).

This study also took Cole and colleagues' (2004) suggestion to use multiple measures to provide converging evidence for emotion regulation by examining second-by-second changes in action readiness measured at the neurophysiological level (indexed by EEG asymmetry) alongside phenomenological emotional processes in daily life (measured via EMA). Specifically, it tested the hypothesis that mothers who showed a pattern of neurophysiological activation characterized by both approach and withdrawal orientation would show more adaptive emotion regulation during parenting-related challenges in daily life.

This study focused on mothers of children during the first 2 years of life. From an emotional perspective, infancy and early toddlerhood are uniquely challenging times for parents.

In addition to the increased parent positive and negative emotion (Miller & Rukstalis, 1999) and anxious preoccupation (Swain, 2008; Swain, Lorberbaum, Kose, & Strathearn, 2007) that typically occurs in the months after a child's birth, infants' limited self-regulatory capacity requires parents to be constantly attuned and responsive to infant cues (Cole et al., 1994; Thompson 1994; Tronick, 1989), with implications for parents' own emotional experience. The second year presents different challenges for parents, as children develop the ability to move independently and communicate verbally, and thus to assert autonomy. These developmental attainments, although joyful for parents, may also lead to situations that elicit parental anxiety and frustration (LeDonne et al., under review). Furthermore, children's development is sensitive to variations in parent emotion during this period of time. For example, maternal depression occurring during the first and second years postpartum is associated with increases in child behavioral problems and anxiety during the preschool years, even if maternal depression has remitted by this time (Dawson, Ashman, & Carver, 2000). Thus, the first two years postpartum are a critical period in which to study parental emotion.

Hypothesis #1

It was predicted that mothers would demonstrate different second-by-second trajectories of action readiness measured at the neurophysiological level by EEG (indexed by frontal cortical asymmetry, in which larger scores indicate more left asymmetry) while viewing videos of their own infants exhibiting distress. Specifically, it was expected that each mother would fall into one of three second-by-second trajectory groups showing one of the following patterns of action readiness: (1) decreasing asymmetry, indicating down-regulation of approach readiness, (2) increasing asymmetry, indicating up-regulation of approach readiness, (3) a dynamic, changing pattern characterized by both a decrease in asymmetry (down-regulation of approach readiness hypothesized to indicate empathic identification with infant distress), and an increase in asymmetry (up-regulation of approach readiness, interpreted as being conducive to helping behavior; see Figure 1).

Hypothesis #2

It was predicted that mothers' subjective experiences of specific emotions would be associated with their self-reported action readiness, actual behavioral engagement and disengagement, emotion regulation (specific coping strategies and regulation of action readiness), and stress responses (all measured by EMA) during parenting situations that evoked maternal negative emotions in day-to-day life. It was predicted that the direction of these associations would depend on each emotion's unique appraisal/action readiness profile. Specifically, it was predicted that:

(a) Emotions that are characterized by approach readiness and appraisal of goals as attainable and not blocked or threatened (happiness and confidence) would be positively related to self-reported readiness to engage, actual behavioral engagement, regulation of behavioral engagement and disengagement, use of adaptive, engaged coping strategies, and inversely related to readiness to disengage, actual behavioral disengagement, and stress responses.

(b) Emotions that are characterized by passive approach or withdrawal readiness and appraisal of goals as already attained (contentment and pleasure) would be positively related to self-reported readiness to engage, actual behavioral engagement, regulation of behavioral engagement and disengagement, use of engagement coping strategies, and inversely related to readiness to disengage, actual behavioral disengagement, and stress responses.

(c) Emotions that are characterized by behavioral withdrawal and appraisal of goals as unattainable (sadness, discouragement) would be positively related to self-reported readiness to disengage, actual behavioral disengagement, and disengaged stress responses and inversely related to readiness to engage, actual behavioral engagement, regulation of disengagement and engagement, use of engagement coping strategies, and engagement stress responses.

(d) Emotions that are characterized by approach readiness and appraisal of goals as attainable but blocked or threatened (angry, irritation, concerned, worried) would be positively related to self-reported readiness to engage, actual behavioral engagement, and engaged stress responses, and inversely related to readiness to disengage, actual behavioral disengagement, regulation of disengagement and engagement, use of engagement coping strategies, and disengagement stress responses.

Hypothesis #3

It was hypothesized that mothers' EMA-reported emotion regulation during situations that evoked negative emotion and that were parenting-related would be predicted not only by emotions experienced concurrently (see Hypothesis #2), but also by emotions experienced earlier in the day.

Hypothesis #4

It was hypothesized that mothers' regulation of action readiness at the neurophysiological level (indexed by second-by-second trajectories of EEG asymmetry) in response to videos of their own infants' distress would be related to their EMA-reported emotion regulation during day-to-day parenting challenges. Specifically, it was predicted that:

(a) Greater likelihood of being in the *decreasing approach readiness trajectory group* would be directly related to day-to-day (EMA-measured) self-reported readiness to disengage, actual behavioral disengagement, regulation of disengagement, and disengagement stress responses, and inversely related to readiness to engage, actual behavioral engagement, and engagement coping and stress responses.

(b) Greater likelihood of being in the *increasing approach readiness trajectory group* would be directly related to day-to-day self-reported readiness to engage, actual behavioral engagement, and engagement coping strategies and stress responses, and inversely related to readiness to disengage, actual behavioral disengagement, and disengagement stress responses.

(c) Greater likelihood of being in the *dynamic approach readiness trajectory group* (interpreted as mothers' initial empathic responding with infant distress, followed by an up-regulation of approach that is conducive to helping behavior), would be directly related to adaptive emotion regulation and inversely related to stress responses during day-to-day parenting challenges. Although it was predicted that greater likelihood of being in the *increasing approach readiness group* or the *dynamic approach readiness trajectory group* would be associated with adaptive emotion regulation, it was predicted that the association would be stronger for the *dynamic approach readiness* group than for the *increasing approach readiness* group.

Chapter 2. METHOD

Participants

This study consisted of mothers of young children living in the Central PA region. A total of 101 mothers participated in laboratory-based EEG data collection when their infants were 6-8 months old (study Phase I); 56 of these mothers were successfully re-recruited to participate in ecological momentary assessment (EMA) data collection when their children were 12-24 months old (study Phase II). Mothers were initially recruited from the community using newspaper ads, fliers, and letters to families in the Penn State Child Study Center's Families Interested in Research Studies Database. Recruitment was limited to right-handed women (a standard of EEG research, given relations between handedness and neural organization), who were fluent in English, and living with their children. Exclusionary criteria included mothers whose infants were born very prematurely (less than 32 weeks gestational age at birth) or had low birth weight, chromosomal abnormalities or significant perinatal complications (based on maternal report).

On average, the 101 mothers who participated in Phase I of the study were 30 years old (*SD* = 4.93; Range = 20 - 44). On the date of the lab visit, the target children for the study ranged in age from 5-8 months (*M* = 6.49, *SD* = .70), however, 70% of mothers also had at least one other child (*M* number of children = 2.22; *SD* = 1.11; range = 1 – 6). Exactly half of the target children were female. Ninety-eight mothers were married or cohabitating with a partner, and three were single. Although the sample was ethnically homogenous (97% Caucasian, 3% Asian), there was a large range in annual family income, with a minimum of $4,368 to a maximum of $250,000 (*M* = $66,749; *SD* = $41,486). In regard to education, 69% of mothers had earned at least a Bachelor's degree. Just over half of mothers (58.4%) reported being employed (32 full-time and 22 part-time).

The 55 mothers who completed Phase II of the study were, on average, 31.7 years old (*SD* = 4.45; Range = 23 – 41). On the first date of EMA, target children were, on average, 19.47 months (*SD* = 3.47; Range = 14 – 25). The majority of mothers (69.1%) had more than one child (*M* = 2.18; *SD* = 1.07; Range = 2 - 6); furthermore, 60% of mothers had additional young children (i.e. under the age of 6; *M* = 1.85; *SD* = .85; Range = 1 - 4). Thirty-one of the target children were female (56%). Fifty-three mothers were married or cohabitating with a partner, one was widowed, and one was legally separated from her husband. Consistent with the Phase I sample, mothers were ethnically homogeneous (98% Caucasian, 2% Asian), but socioeconomically diverse (*M* annual income = $73,169; *SD* = $36,522; Range = $5,000 – $200,000). In regard to education, 78% of mothers had earned at least a Bachelors' degree. Again, just over half of mothers (34 mothers, 62%) reported being employed; 21 full-time, and 13 part-time (38% and 24% of sample).

Procedure

Phase I. In Phase I, mothers participated in one home and one laboratory visit. During the home visit, infants were videotaped during a procedure designed to generate child stimuli for the EEG assessment. While the mother was out of sight, infants were videotaped while a trained research assistant used brief, standard procedures to elicit infant emotion. Additionally, a video clip of the infant during an emotionally neutral period was 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 presentation during EEG assessment. Clips were selected by choosing the two 10-second periods during which the each of the various emotions was best represented. The home visit also included mothers' completion of a number of questionnaires and mother-infant interactions that were not used in the current analyses.

The Phase I laboratory visit took place at the Human Electrophysiology Facility at the Pennsylvania State University. During this visit, mothers participated in an EEG assessment in which brain electrical activity was recorded using 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), which 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) was obtained. For electrodes placed on the left and right sides of the head, the distance between the midpoints of the two ears were measured. The thirteen standard electrodes were 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 (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. Each mother participated in two 4-minute baseline procedures (one before each condition; described below) following Tomarken and colleagues (Tomarken et al., 1992). The baseline period was divided into 1-minute trials consisting of 4 minutes of eyes open and 4 minutes of eyes closed across the two baseline periods.

Following each baseline procedure, mothers watched one of two 15-minute video presentations. One presentation consisted of a series of 10-second infant emotion clips obtained during that mother's home visit, and the other presentation consisted of the same 10-second emotion clips but with an unfamiliar infant. 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 offset by 15 seconds of a blank screen. Each happy and distress clip was displayed six times (total of 12 clips for each) and the neutral clip was displayed 12 times. The present analyses used EEG data recorded during and immediately following mothers' viewing their *own* infant in the distress condition.

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. Data were referenced to the Cz electrode during data acquisition, and after acquisition, data were re-referenced in order to compute an average reference with Polar Average Reference Effect (PARE) Correction. Since there is no *truly* electrically inactive point on the human body, researchers have suggested that an average reference be used, if data is acquired from at least 20 electrodes (Cacioppo, Tassinary & Berntson, 2007). 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). However, even with high-density EEG nets, activity on the bottom of the scalp is not adequately accounted for because there are not as many electrodes on the bottom of the head as on the top. To address this, a PARE correction, which uses spline interpolation to estimate activity at the bottom of the head (Junghoefer et al., 1999), was used. This interpolation was then used to better determine the average reference.

Phase II. Mothers who agreed to participate in Phase II of the study were scheduled for two home visits approximately 10 days apart and six weekdays of EMA interviews. At the first home visit mothers completed consent procedures, questionnaires (see Measures section), and were provided an answer-only cell phone (e.g., Silk et al., 2003, 2007) to keep for the duration of the study. Following the home visit, mothers completed phone interviews four times a day for six of the following with weekdays.

With one or two exceptions, all phone calls were made by the same trained research assistant who completed the home visit. Calls occurred on Wednesday, Thursday, and Friday of one week, with a break over the weekend, and resumed the following Monday, Tuesday and Wednesday. Placement of the EMA over two weeks was designed to bypass biases that may result from data collection occurring on a particularly easy or difficult week. Data was not collected on Saturdays or Sundays due to the less structured nature of weekends for most families.

To avoid bias (e.g. scheduling activities around data collection) mothers were told that phone calls would occur between the hours of 8:00 a.m. and 8:00 p.m. but were given no further information. Research assistants received a schedule of phone call times for each participant, which were randomly generated and different for each day, but within specified time periods (one call between 8:00 a.m. and noon, one call between noon and 4:00 p.m.; and two calls between 4:00 p.m. and 8:00 p.m.). There were two calls during the last 4-hour block based on pilot research (LeDonne et al., under review) in which mothers reported that dinner-time was the most stressful time of day. If the phone was not answered on the first try, three more attempts were made at random time intervals within the following 20 minutes. If a mother indicated that it was not convenient to talk, the research assistant asked for a better time, but did not specify the exact time of the next call. The duration of phone calls ranged from approximately 5-20 minutes.

Measures

Daily measures of mothers' emotions (appraisals and action readiness). EMA interviews were designed on the basis of a pilot study by Cole and colleagues (Hajal, Cole & Robinson, 2011; LeDonne et al., under review) that used EMA with mothers of 12-36 month old children. During each phone call, mothers were asked what they were doing, feeling, and thinking at three time points (emotion episodes): (1) at the moment the call was received, (2) during the mother's self-identified lowest/worst point in the past hour, and (3) during the mother's self-identified highest/best point in the past hour. Mothers reported when the lowest and highest points occurred, allowing chronological placement of each point in relation to current emotion ratings. Each situation was coded as parenting-related or not, and mothers were asked to rate both positive and negative emotions (happy, content, pleased, confident, sad/discouraged, angry/irritated, concerned/worried, and upset) on a 0 (not at all) to 5 (extremely) Likert scale.

Daily measures of mothers' action readiness. For moments in which mothers reported experiencing some negative emotion, they were asked to rate, on a 0-5 Likert scale, their readiness to approach/engage in the situation ("How much did you feel you *wanted* to be active or engaged in the situation, whether or not you actually were?"), and withdraw/disengage from the situation ("How much did you feel you *wanted* to avoid, withdraw, or disengage from the situation, whether or not you actually did?")

Daily measures of mothers' coping strategies and stress responses. For moments in which mothers reported experiencing some negative emotion, they were also asked, in an open-ended fashion, what they thought and did in the situation. These responses were then coded for specific coping strategies and stress responses according to the empirically-based Responses to Stress Framework (Connor-Smith et al., 2000; Compas et al., 2001). In accordance with the authors, the 19 coping strategies/stress responses identified by this system were collapsed into five groups indicating the level of engagement versus disengagement with the stressor, and the voluntary versus involuntary nature of the response. The groups include *Primary Control Engagement Coping* (consisting of problem solving, perseverance, emotional regulation, emotional expression), *Secondary Control Engagement Coping* (acceptance, distraction, cognitive restructuring, positive thinking, restraint coping), *Voluntary Disengagement Coping* (denial, avoidance, wishful thinking), *Involuntary Engagement* (rumination, negative thinking/intrusive thoughts, emotional arousal, physiological arousal, impulsive action), and *Involuntary Disengagement* (emotional numbing, inaction, escape). Primary and secondary control engagement strategies were further collapsed to obtain a single score for approach-related coping strategies that have been found to be adaptive. Other measures constructed based on this system (e.g., the Responses to Stress Questionnaire; Connor-Smith et al., 2000) have excellent test-retest reliability and internal consistency (see Connor-Smith et al., 2000). Two doctoral-level graduate students coded these data; reliability statistics were good (range of **κ**'s e .65-.93, range of ICC's = .71 - .82).

Data Reduction

EEG data. After acquisition of EEG data, artifacts were screened and transits exceeding 200µv in 640 ms window size were replaced with values interpolated from other channels using spherical splines. Principal components analysis is then used to remove artifacts.

Alpha asymmetry is typically detected in the 8-13Hz range, therefore a bandpass filter of 1-30Hz is used to isolating activity within this range. Data was then divided into two-second epochs 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 consequence of the use of a Hamming window is that good data may be lost at the end of each epoch. To resolve this, the final data used epochs that overlap by 75%.

Fast-Fourier Transform (FFT) is a standard procedure in EEG research; it decomposes an EEG signal into its underlying sine waves to obtain alpha power (average power in 8-13Hz range). The natural log of the alpha power score was taken for each epoch. Alpha asymmetry scores are 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 present 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 are 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.

Action readiness at the neurophysiological level. A variable representing mothers' overall action readiness in response to infant distress was created by averaging mothers' second-by-second EEG asymmetry scores during the 10 seconds of each infant distress stimulus presentation. Because infant distress clips were viewed a total of 12 times, the final action readiness to infant distress variable was comprised of EEG asymmetry scores over 300 seconds (5 minutes). Averaged EEG asymmetry scores during the first infant distress presentation *only* were also examined. Higher scores indicate greater left asymmetry, or, approach action readiness.

Regulation of action readiness at the neurophysiological level. A variable reflecting patterns of regulation of action readiness was created by estimating trajectories of mothers' second-by-second EEG asymmetry to infant distress stimuli (during the 10 seconds of the infant distress video) via latent growth curve and latent class growth analysis (Muthen & Muthen, 2000; see Results section).

EMA data. EMA yielded discrete emotion ratings and reports of emotion regulation strategy use for approximately 72 emotion episodes per participant. Analyses were conducted for moments in which the mother experienced negative emotion in relation to a parenting-related event.

Emotions. Mothers rated each emotions on a 0 (not at all) to 5 (extremely) Likert scale: happy, confident, pleased, content, sad/discouraged, irritated/angry, concerned/worried, and upset. Upset was not used in the present analyses due to its not being theoretically or empirically associated with a specific appraisal/action readiness profile.

Regulation of action readiness at the phenomenological level. The Likert-scale rated items assessing mothers' action readiness (how much they wanted to engage in or disengage from the situation, whether or not they actually did) , along with those assessing actual behavior (i.e., "How active or engaged in the situation were you?" and "How much did you avoid, withdraw, or disengage from the situation?") were subjected to latent class analysis to examine whether classes could be formed to reflect moments in which mothers regulated their desired behavioral engagement or disengagement. Analysis of the 1,036 parenting-related moments in which behavioral engagement and disengagement were assessed indicated that a 4-class model fit the data best. The Lo-Mendell-Rubin test suggested that the 6-class model did not have a significantly better fit than the 5-class model (see Table 1). Although the 5-class model fit better than the 4-class model according to the Lo-Mendell-Rubin test, as well as fit statistics (AIC and BICs), two of the classes in the 5-class model were quite similar, and the model was unidentified. Thus, further analyses were conducted based on the 4-class solution (see Figure 2).

Fully disengaged group. The first class comprised 4.3% (n = 43) of the moments and was defined by moments in which mothers reported little desire to engage (M = 2), high desire to disengage (M > 4), high actual disengagement and low actual engagement (M > 4, M = 2.4, respectively).

Mixed engagement group. The second group comprised 19% (n = 197) of moments and was defined by moments in which mothers appeared ambivalent; they indicated moderate desire to disengage (M = 3) and low desire to engage (M = 2), but reported actually disengaging only a little (M = 2) and engaging moderately (M = 3).

Fully engaged group. The third group comprised almost half of the moments (49.1%, *n* = 517); it was defined by moments in which mothers desired and were fully engaged (desired disengagement *M* < 1, actual disengagement *M* = 0, desired and actual engagement *M*s > 4).

Regulated desire to disengage. The fourth and final group was the second most frequent group of moments (27.6%, *n* = 278). It was defined by moments in which mothers reported moderate desire to disengage (*M* = 3), little desire to engage (*M* = 2.2), but did not actually disengage (*M* = 0), and actually engaged to a high degree (*M* > 4).

These classes showed excellent differentiation from one another; moments had a greater than 92% probability of actually falling into the class in which they were assigned (Range = 92.4% to 99.7%). Therefore, a single variable was created to indicate a mother's level of regulation of disengagement. Data was only included for moments that fell into Classes 1, 2, and 4, because each involved at least moderate desire to disengage.

Data were recoded so that *Fully Disengaged* (Class 1) moments received the lowest score of 1; *Mixed* (Class 2) moments received the middle score of 2, given that there was some regulation of disengagement (desire to disengage *M* = 3, actual disengagement *M* = 2); and moments in the *Regulated Desire to Disengage* group (Class 4), received the highest score of 3, given that there was no actual disengagement despite a moderate desire to disengage (*M* = 3).

Coping strategies and stress responses. As noted above, mothers' reports of what they thought and did during parenting challenges were coded for specific coping strategies and stress responses according to the Responses to Stress framework (Compas et al., 2001; Connor-Smith et al., 2000). In accordance with previous work using this framework (i.e., Wadsworth, Rieckmann, Benson & Compas, 2004), proportion scores were created in order to control for individual differences in total number of strategies reported. The score was created by dividing the each category score by the total number of strategies reported (e.g., Total # of Involuntary Engagement Stress Responses/Total # of Coping Strategies *and* Stress Responses).

Analytic Strategy

Latent growth curve analysis was used to test the hypothesis that mothers would demonstrate different second-by-second trajectories of neurophysiological action readiness (measured via EEG frontal cortical asymmetry, in which larger scores indicate more left asymmetry) while viewing videos of their own infants exhibiting distress. Following previous research examining state-related changes in EEG asymmetry (Harmon-Jones et al., 2003; Killeen & Teti, 2012), baseline EEG asymmetry was included as a covariate.

Multilevel modeling was used to test hypotheses involving EMA data. Multilevel modeling is often used with EMA data due to its ability to handle (1) nested or hierarchical data (i.e., moments nested with days, which are further nested within individuals) that violate assumptions of independence, (2) missing data, and (3) data in which the time elapsed between multiple measurements are not always equidistant.

Chapter 3. RESULTS

EEG

Descriptive Statistics. EEG alpha power and asymmetry scores were examined in both mid-frontal (6 electrodes surrounding F4 and F3) and lateral-frontal (6 electrodes surrounding F8 and F7) regions. Descriptive statistics are provided for data at the second-by-second level as well as averaged across all seconds of the baseline and infant distress conditions (see Tables 2-5). All tables provide descriptive statistics for the *first* infant distress stimulus presentation and for all six presentations averaged across each infant distress condition. Examination of bivariate correlations demonstrated no statistically significant associations between EEG and demographic variables.

On average, mothers demonstrated slightly greater right- relative to left-hemispheric asymmetry during all conditions, whether examined on a second-by-second or averaged basis. However, standard deviations and ranges suggested substantial between-person variability.

Latent growth curve analysis. The first hypothesis was that mothers would demonstrate differing second-by-second trajectories of EEG asymmetry measured at the neurophysiological level during the infant distress condition; specifically, that variability in asymmetry scores across mothers could be accounted for by three distinct trajectory patterns (see Figure 1): (1) decreasing asymmetry, indicating down-regulation of approach readiness, (2) increasing asymmetry, indicating up-regulation of approach readiness, (3) a dynamic, changing pattern characterized by an initial decrease in asymmetry (down-regulation of approach readiness hypothesized to indicate empathic identification with infant distress), followed by an increase (up-regulation of approach readiness). To prepare the data for testing this prediction, traditional latent growth curve analysis was conducted for each region (F4-F3 and F8-F7, including baseline

EEG asymmetry as a covariate), followed by latent class growth analysis. Each model included a quadratic effect due to the nonlinear nature of EEG data. Mplus was used to conduct all latent growth curve models.

The best fitting models for both mid- (F4F3) and lateral-frontal (F8F7) second-by-second asymmetry models fit the data well (F4F3: χ^2 = 66.85, p > .10; RMSEA = .05 CFI = .97; SRMR = .06 and F8F7: χ^2 = 63.20, p > .10; RMSEA = .03; CFI = 1.0.; SRMR = .04), however, the slope and quadratic effects were not statistically significant. Additionally, for both models, there was significant between-person variability in the intercepts (residual variance, $\psi_{\infty 0}$ = .09 and .04, p's < .001), but not in the slope or quadratic effects. This suggested that mothers' asymmetry scores differed at the start of the stimulus, but showed the same general trajectory over time. Thus, the prediction that mothers would demonstrate differing second-by-second trajectories of EEG asymmetry during the infant distress condition was not supported. As a result, further tests of hypotheses with EEG data used the traditional approach of averaged alpha power and asymmetry scores over each condition.

Ecological Momentary Assessment

The full ecological momentary assessment protocol was completed by 55 participants, for a total possible of 1,320 phone calls (55 participants * 24 calls per participant), and 3,960 unique moments (*Current Moment*, *Low Point*, *and High Point* moments for each of 1,320 possible calls). Consistent with other EMA studies, each participant had at least some missing data. A total of 810 moments (20%) were missing, due to a missed call, to the mother being unable to complete a call, or to two of the moments within a call being the same (i.e., the mother reported that her *Low Point* of the hour was the *Current Moment).* This left a total of 3,150 moments for which data was available; 1,754 of these moments involved the target child (55.7%; parent was either with, doing something for, or thinking about the child), and of those, negative emotion was endorsed in 1,036 (32.8% of all moments; 59% of target child-related moments).

Descriptive statistics and correlations. Descriptive statistics for the EMA self-reported emotion, action readiness, behavioral engagement and disengagement, and emotion regulation (coping strategies, stress responses, and regulation of action readiness) variables are provided in Table 6. On average, mothers reported moderate levels of positive emotions (*M*s= 2.78 – 3.11) and slight levels of negative emotions (*M*s = .63 - .73). For situations in which they experienced negative emotion, mothers reported on average that they wanted to disengage (self-reported readiness to withdraw) “a little” (*M* = 1.84), but only actually disengaged “very slightly” (*M* = .81); that they wanted to engage (self-reported readiness to approach) “somewhat/moderately” (*M* = 3.12) and actually engaged “quite a bit” (*M* = 3.89). For situations in which they experienced negative emotions, on average, 79% of mothers’ self-reported thoughts and actions could be classified as engagement coping strategies (63% primary control and 16% secondary control engagement coping), while 21% could be classified as stress responses (8% voluntary disengagement, 13% involuntary engagement, and .3% involuntary disengagement). When considering all 981 moments for which mothers offered answers that could be coded as coping strategies or stress responses, at least one coping strategy was reported on 95.6% of moments (primary control engagement on 89.4% and secondary control engagement on 33.4% of moments), and at least one stress response was reported on 46.7% of moments (voluntary disengagement on 19%, involuntary engagement on 31.3%, and involuntary disengagement on .5% of moments). Because involuntary disengagement was reported in only 5 moments, it was not examined separately in analyses.

Examination of the range of intraindividual (i.e., within-person) means suggested, however, that the average levels of emotion, action readiness, actual behavioral engagement and disengagement, and emotion regulation were at times very different from mother to mother. For example, one mother reported “a little” happiness during moments with her child (on average), while another mother reported feeling “extremely” happy during these moments (on average; see Table 6 for statistics). There was also between-person variability in the levels of emotion, action readiness, and actual behavior that individual mothers experienced. Finally, there was substantial within-person variability in emotions (range of ICCs = .08 - .26), action readiness (disengagement ICC = .15; engagement ICC = .21), actual disengagement (ICC = .14), actual engagement (ICC = .23), and emotion regulation (ICCs range = <.01 - .13) suggesting that these states were context-dependent.

It is notable that there was between-person variability in the number of target child parenting related moments reported by each mother (from 11 to 57). Thus, the intraindividual means, standard deviations, and intraclass correlations were based on a different number of observations for each participant. Note that *n*’s for the actual behavioral engagement and disengagement and regulation variables were smaller than for other variables as these items were presented only when participants endorsed negative emotion.

Bivariate correlations among momentary and intraindividual EMA variables are presented in Tables 7 and 8. Positive emotions were highly significantly correlated with one another (*r*’s range = .67 - .92), thus, averaged positive emotion variables were created (momentary and intraindividual). Because specific hypotheses were made for each discrete emotion, further analyses examined each positive emotion individually as well as the composite positive emotion score.

As for relations with demographic variables, annual family income was associated with averaged engagement and disengagement: greater income was significantly associated with greater actual engagement ($r = .32$, $p < .05$), and marginally associated with less readiness to disengage ($r = -.25$, $p = .07$) and greater readiness to engage ($r = .26$, $p = .07$). Older child age was related to greater average confidence ($r = .28$, $p < .05$) and contentment ($r = .25$, $p = .07$).

Multilevel regression modeling. Multilevel modeling (MLM) was used to test Hypotheses #2 regarding relations between self-reported emotions, action readiness, behavioral engagement and disengagement, and emotion regulation for the 1,036 moments in which mothers endorsed negative emotion. MLMs were conducted in R using the ‘nlme’ package and employed restricted maximum likelihood (REML) estimation. Notably, although negative emotion variables were skewed and kurtotic when considering all 1,770 parenting situations, they were normally distributed in the subsample of moments used for the following analyses. For each model, the dependent variable was predicted by both the momentary and the intraindividual mean for emotion for each participant. Momentary emotion variables were entered at Level 1, while intraindividual mean emotions were entered at Level 2. The following multilevel system of equations, where *i* represents individuals and *t* indicates time, were tested:

$$\text{Behavior/Regulation}_{ti} = \beta_{0i} + \beta_{1i}(\text{MomentaryEmotion}_{ti}) + e_{ti}$$

where:

$$\beta_{0i} = \gamma_{00} + \gamma_{01}(\text{IntraindividualEmotion}_{i}) + u_{0i}$$

$$\beta_{1i} = \gamma_{10} + \gamma_{11}(\text{IntraindividualEmotion}_{i}) + u_{1i}$$

or, as a single mixed-effects model:

$$\text{Behavior/Regulation}_{ti} = \gamma_{00} + \gamma_{01}\text{IntraindividualEmotion}_{i} + \gamma_{10}\text{MomentaryEmotion}_{ti} + \gamma_{11}\text{IntraindividualEmotion}_{i}*\text{MomentaryEmotion}_{ti} + u_{0i} + u_{1i}\text{MomentaryEmotion}_{ti} + e_{ti}$$

Level 1 variables were centered around their intraindividual means, and Level 2 variables were centered around the grand mean (Bolger, Davis, & Rafaeli, 2003; Schwartz & Stone, 1998). Intercepts and slopes were allowed to vary across Level 2 units in order to test for cross-level interactions. Scatter and quantile-quantile plots were examined to assess diagnostics of each model (distributions and means of Level 1 and residual errors); assumptions were met unless otherwise stated in text. When necessary, interaction effects were probed by examining regions of significance of simple slopes using the Johnson-Neyman technique (Preacher, Curran, & Bauer, 2006). Tables 9-24 show the results of MLMs predicting behavioral engagement, disengagement, regulation, and coping strategies, and stress responses. The significance level for all associations reported in text is $p < .05$ unless otherwise specified.

Happiness and confidence. It was hypothesized that happiness and confidence, which are characterized by approach readiness and appraisal of goals as attainable, would be positively related to maternal momentary report of behavioral engagement and use of engaged emotion regulation strategies, and inversely related to behavioral disengagement and use of involuntary and disengaged emotion regulation strategies. These hypotheses were mostly supported. Higher momentary and intraindividual happiness were associated with more desired engagement (γ_{10} =.29, $p < .05$; $\gamma_{01} = .32$, $p < .10$), less desired ($\gamma_{10} = -.37$; $\gamma_{01} = .32$, $p < .10$) and actual disengagement ($\gamma_{10} = -.10$; $\gamma_{01} = .37$). Higher intraindividual happiness was marginally related to greater actual engagement ($\gamma_{01} = .30$, $p < .10$). In terms of regulation and coping strategies, greater intraindividual happiness was associated with more regulation of disengagement (γ_{01} = .17), while greater momentary happiness was associated with a higher proportion of coping strategies (γ_{10} = .01) and a lower proportion of involuntary engagement stress responses (γ_{10} = -.01).

Higher momentary and intraindividual confidence were associated with less desired (γ_{10} = -.48; γ_{01} =.-.34) and actual disengagement (γ_{10} = -.17; γ_{01} = -.22). Intraindividual confidence was also associated with actual engagement (γ_{01} = .31). There were significant cross-level interaction effects (γ_{11}'s = -.15 and -.12) for desired and actual disengagement; probing of these effects indicated that the inverse relation between momentary confidence and actual disengagement was not significant for mothers in the lowest 20% of intraindividual confidence (*n* = 11), suggesting that momentary confidence was related to less disengagement only for mothers who were typically at least somewhat confident. In terms of regulation and coping strategies, greater momentary confidence was only associated with a higher proportion of coping strategies (γ_{10} = .02).

In support of hypothesis 1a, happiness and confidence, which are characterized by approach readiness and appraisal of goals as attainable, were generally related to more engagement, less disengagement, greater regulation of the desire to disengage, and greater use of coping strategies versus stress responses.

Contentment and pleasure. It was hypothesized that contentment and pleasure, which are characterized by passive approach or withdrawal readiness and appraisal of goals as already attained, would be positively related to maternal momentary reports of behavioral engagement and use of engaged, voluntary emotion regulation strategies, and inversely related to behavioral disengagement and involuntary and/or disengaged emotion regulation. Momentary and intraindividual contentment was positively related to desired engagement (γ_{10} = .30; γ_{01} = 33), and inversely related to desired (γ_{10} = -.41; γ_{01} = -.39) and actual disengagement (γ_{10} = -.12; γ_{01} = -.31). Intraindividual contentment was also related to actual engagement (γ_{01} = .34). In terms of regulation and coping strategy use, higher momentary contentment was related to a greater proportion of coping strategy use (γ_{01} = .02) and to a lower proportion of involuntary engagement stress responses (γ_{01} = -.02).

Similar to contentment, greater momentary and intraindividual pleasure were related to less desired (γ_{10} = -.39, $p < .05$; γ_{01} = -.32, $p < .10$) and actual (γ_{10} = -.11; γ_{01} = -.26) disengagement. Momentary pleasure was also related to more desired engagement (γ_{10} = .29). In terms of regulation, greater intraindividual pleasure was related to greater regulation of the desire to disengage (γ_{10} = .16, $p = .06$) and a higher proportion of voluntary disengagement responses, and momentary pleasure was related to a lower proportion of involuntary engagement stress responses (γ_{10} = -.01). Intraindividual pleasure was related to less desired (γ_{01} = -.32, $p < .10$) and actual disengagement (γ_{01} = -.26), and more regulation of the desire to disengage (γ_{01} = .16, $p < .10$).

In support of hypothesis 2b, contentment and pleasure, which are characterized by passive approach or withdrawal readiness and appraisal of goals as already attained, were generally related to more engagement, less disengagement, greater regulation of the desire to disengage, and greater use of coping strategies versus stress responses.

Positive emotion composite score. Greater momentary and intraindividual positive emotion were related to more desired engagement (γ_{10} = .39; γ_{01} = .40), less desired (γ_{10} = -.51; γ_{01} = -.45) and actual disengagement (γ_{10} = -.15; γ_{01} = -.36). Greater intraindividual positive emotion was also associated with more actual engagement (γ_{01} = .35, $p < .05$). In terms of regulation and coping strategies, greater intraindividual positive emotion was associated with greater regulation of disengagement (γ_{01} =.16, p = .07), and greater proportion of coping strategies (γ_{01} = .02), specifically, less involuntary engagement (γ_{01} = -.02). Probing of the marginally significant cross-level interaction effect (γ_{11} = .10, p = .07) for regulation of disengagement did not provide further support for moderation.

Sadness/discouragement. It was hypothesized that sadness, which is characterized by behavioral withdrawal and appraisal of goals as unattainable, would be related to maternal momentary report of behavioral disengagement and disengaged stress responses and inversely related to behavioral engagement and engaged coping strategies. As predicted, greater momentary and intraindividual sadness were related to more desired (γ_{10} = .38, $p < .05$; γ_{01} =.49, $p < .10$) and actual disengagement (γ_{10} =.17; γ_{01} = .37). Momentary sadness was also inversely related to desired engagement (γ_{10} = -.21). Probing of the significant interaction effect for actual disengagement (γ_{11} = -.23), indicated that its association with momentary sadness was not significant for mothers whose intraindividual sadness was greater than 1 standard deviation above the mean. Thus, momentary sadness led to actual behavioral disengagement for mothers who did not report high general sadness.

In terms of regulation, greater momentary and intraindividual sadness were related to a higher proportion of involuntary engagement stress responses (γ_{10} =.01, $p < .10$; γ_{01} = .06, $p < .05$). The model predicting the regulation of disengagement from sadness did not converge.

In support of hypothesis 2c, sadness, which is characterized by behavioral withdrawal and appraisal of goals as unattainable, was generally related to less desired engagement, more desired and actual disengagement, and less use of adaptive coping strategies. Contrary to prediction, it was unrelated to disengagement stress responses, but was related to more involuntary engaged stress responses.

***Irritation/anger and concern/worry*.** It was hypothesized that greater irritation/anger and concern/worry, which are characterized by approach readiness and appraisal of goals as attainable but blocked or threatened, would be related to more behavioral engagement and use of engaged emotion regulation strategies (both voluntary and involuntary), and inversely related to behavioral disengagement and disengaged emotion regulation strategies (both voluntary and involuntary). Contrary to hypotheses, momentary and intraindividual irritation/anger was significantly associated with greater desired (γ_{10} =.52; γ_{01} =.66) and actual disengagement (γ_{10} =.27; γ_{01} =.47). Greater momentary irritation was also related to less desired engagement (γ_{10} = -.25).In terms of regulation, greater intraindividual anger was, as expected, significantly associated with less regulation of disengagement (γ_{01} = -.37). Greater momentary and intraindividual irritation was associated with a smaller proportion of coping strategies (γ_{10} = -.03; γ_{01} = -.06); this relation seemed to be driven by the higher proportion of involuntary engagement (γ_{10} =.03; γ_{01} =.05), and not voluntary disengagement (γ_{10} =.003; γ_{01} =.01, p's > .10), stress responses.

In line with expectations, greater momentary concern/worry was associated with more actual engagement (γ_{10} =.07); for all other models examining the impact of concern/worry on behavioral engagement and disengagement, significant interaction effects had to be examined. Contrary to expectations, greater momentary concern worry was related to more desired disengagement, but only for mothers who were higher than average in intraindividual concern/worry (simple slope at upper bound of region of significance = .10, $p < .05$; γ_{10}= .20, p = .07, n = 13; for mothers above average: γ_{10} = .15, $p < .05$, n = 24). Probing of other interaction effects suggested that main effects for momentary concern/worry were present for only 1-3 mothers in the sample (n = 1 for actual disengagement and n = 3 for desired disengagement), thus, effects for those models were not considered generalizable. In terms of regulation, greater concern/worry was related to a higher proportion of involuntary engagement stress responses (γ_{10} = .02). Probing of the significant interaction effect for regulation of disengagement showed that a main effect was only present for 5 mothers in the sample; thus, as noted above, effects for that model were not considered generalizable.

Overall, results for models testing the effects of irritation and concern did not support hypothesis 2d, with the exception was that greater irritation/anger and concern/worry were associated with a higher proportion of involuntary engaged stress responses. Otherwise, the effects for irritation were similar to those of sadness, showing that it was related to less engagement and more disengagement. As expected, concern/worry was modestly related to more actual engagement for the full sample, but was associated with more desired disengagement for mothers who were high in intraindividual concern/worry.

Positive and negative emotion. A series of analyses were then conducted with both the positive and negative emotion as predictors. Due to the high correlations between positive emotions, the composite score was used. Similarly, sadness and irritation variables were combined due to their strong, linear relation. Concern was examined separately. Unfortunately, this computationally intensive model did not converge for most of the outcome variables tested. For the model predicting desired disengagement, there were significant effects for momentary positive (γ_{10} = -.31) emotion, combined sadness/irritation (γ_{10} = .42) and concern (γ_{10} = -.14). There was also a significant effect for intraindividual sadness/irritation (γ_{10} = .97). It is notable that when the variance related to sadness and irritation was examined separately from concern,

concern was strongly related to *less* desired disengagement, as predicted by emotion theory. Results were consistent when predicting desired engagement: positive emotion and concern were related to more desired engagement (γ_{10} = .38 and .16), and sadness/irritation was significantly related to less (γ_{10} = -.15).

Models were then conducted with only positive emotion and the sadness/irritation composite variables (concern was removed). The desire to disengage was significantly associated with momentary positive emotion (γ_{10} = -.28), momentary sadness/irritation (γ_{10} = .40) and intraindividual sadness/irritation (γ_{10} = .97). Desired engagement was associated with both momentary (γ_{10} = .31) and intraindividual positive emotion (γ_{10} = .40); its relation to momentary sadness/irritation was marginally significant (γ_{10} = -.12, p = .09). Similarly, actual engagement was inversely associated with intraindividual positive emotion (γ_{10} = .47), but only marginally significantly associated with intraindividual sadness/irritation (γ_{10} = .45, p = .07). There were no significant effects for the model with regulation of disengagement. The models for actual disengagement, coping strategies, and stress responses did not converge.

***Lagged variable analysis*.** To test the hypothesis that emotions experienced earlier in the day would influence behavioral engagement, disengagement, and regulation later in the day, lagged variables (t-1) were created and incorporated into multilevel models. For the most part, lagged momentary emotion variables were not related to later engagement, disengagement, and regulation (although intraindividual emotions persisted as significant predictors in many models). There were a few exceptions. Earlier positive emotion was related to later desired disengagement (γ_{10} = .11), while earlier concern was related to later desired disengagement (γ_{10} = -.23) *and* engagement (γ_{10} = .16). Earlier sadness was related to less actual engagement in later parenting challenges (γ_{10} = - .11) while earlier irritation was related to more actual disengagement (γ_{10} = .10).

General notes on multilevel models. Examination of random effects across all models indicates that variance in the slopes was quite low for all models, suggesting that, generally, the within-person associations documented were similar for across mothers in the sample. The slope and intercept variance, however, were moderately to highly correlated across most models (see Tables 9-24).

It is notable that approximately 10% of the models tested did not converge. This may have been due to non-normal error distributions of some of the regulation variables. The regulation of disengagement variable was ordinal, and the coping strategy and stress response scores were proportional, neither of which are optimal for MLM.

As noted, two of the demographic variables (family income and child age) were correlated with some of the action readiness, actual engagement and disengagement, and emotion variables. Models involving predictor or outcome variables that were correlated with demographic variables were run both with and without these demographic variables included as covariates; patterns of results did not change.

EEG and EMA

The fourth hypothesis predicted associations between EEG asymmetry trajectory groups and EMA-reported behavioral engagement, disengagement, and regulation. As latent class growth analyses did not yield multiple trajectory groups, the EEG-EMA hypotheses were tested with multilevel models predicting behavioral engagement, disengagement, and regulation from traditional averaged alpha power and EEG asymmetry scores during the baseline and infant distress conditions. Both EEG and EMA data were available for 48 mothers.

Correlations. Correlations between EEG asymmetry scores and intraindividual means for EMA-reported behavioral engagement, disengagement, and regulation were conducted (20 bivariate correlations, and 20 partial correlations with baseline asymmetry included as a covariate). EEG asymmetry scores were not associated with any of the EMA behavioral engagement, disengagement, or regulation intraindividual means. Alpha power during infant distress, however, was significantly associated with proportion of coping strategies (range of *r'*s = -.34 to -.37) and voluntary disengagement stress responses (range of *r'*s = .36 to .41).

Multilevel regression models. MLM was used to test associations among action readiness at the neurophysiological level (measured by EEG asymmetry) and day-to-day emotion regulation. Alpha power (which is inversely related to activity) during both baseline and infant distress were added to the models predicting coping strategy use and voluntary disengagement stress responses from positive and negative emotion composite scores. Separate models were conducted for alpha power at each site (F4, F3, F8, F7). Higher alpha power (lower frontal activity) during infant distress was related to a lower proportion of coping strategies (F4 and F3 γ_{10} = -.08; F8 and F7 γ_{10} = -.09) and a higher proportion of voluntary disengagement stress responses (F4 and F3 γ_{10} = .05; F8 and F7 γ_{10} = .06) at each site.

In sum, the hypothesis that mothers' action readiness at the neurophysiological level in response to videos of their infants in distress (as indexed by EEG asymmetry) would be associated with phenomenological action readiness, behavioral engagement and disengagement, and regulation was not supported. However, greater activity across both hemispheres of the frontal cortex during the infant distress videos was associated with use of coping strategies and stress responses in response to day-to-day parenting challenges.

Chapter 4. DISCUSSION

This study aimed to further knowledge of the emotional processes involved in parenting young children with the ultimate goal of adding to a knowledge base that will inform interventions for at-risk families. Emotional processes were conceptualized from a functionalist perspective, defining them as contextually driven appraisals, action readiness, and regulation that unfold over time as a process rather than as static or discrete events (Campos et al., 1994; Thompson, 1994). The study investigated how parental emotions unfold in two contexts with two different time-based measurement approaches and tested potential relations between these two approaches. It examined mothers' automatic, rapid, unconscious processing using EEG asymmetry as an index of action readiness at the neurophysiological level, and mothers' self-reported emotions, motivations, and actions as indices of emotion at the phenomenological level.

The main findings indicated that positive maternal emotions were related to better emotion regulation during challenging parenting situations, while negative emotions were related to less emotion regulation. Although this assertion may seem self-evident, this is an important phenomenon to document scientifically as it can ultimately inform interventions for at-risk parents. Additionally, it showed that parents' in-the-moment emotion regulation is influenced by their general, "trait-like" patterns of emotional responding and their emotional experience in that particular situation. This study considered parental emotional processes in terms of both automatic, rapid, and unconscious physiological responding as well as the more phenomenological aspects revealed in mothers' self-reports of conscious emotional, cognitive, and behavioral states in daily life.

Mothers' Automatic, Rapid, Unconscious Emotion Processing

Emotion is defined by appraisal and action readiness (Arnold, 1960; Frijda, 1986; Barrett & Campos, 1987), and EEG has been used to measure action readiness at the neurophysiological level (Coan & Allen, 2004) by examining hemispheric asymmetry. The time series nature of EEG data makes it particularly advantageous to use in the study of emotion as a process, as it captures dynamic changes in action readiness over time that may be indicative of regulation. Contrary to predictions, however, growth curve models of second-by-second EEG asymmetry did not reveal systematic change in mothers' action readiness over the first 10 seconds of exposure to videos of infant distress. Furthermore, analyses of EEG asymmetry trajectories did not reveal the expected groups of mothers. Patterns of second-by-second change in EEG asymmetry were found in one study (Light et al., 2009), but differences in the designs of that study and the present study may explain dissimilar findings. Specifically, the present study examined emotional action readiness at the neurophysiological level in response to a video, while Light and colleagues did so during an interpersonal task. Thus, the shifts in action readiness found in the Light sample may have been due to participants being actively involved in a task as opposed to more passively watching a video. This passive versus active differentiation between the two studies is especially relevant when considering the present study's interest in approach readiness and behavior. Future research investigating dynamic changes in parent action readiness could benefit from the use of ambulatory neurophysiological recording methods (i.e., Wilhelm & Grossman, 2010), which would allow EEG asymmetry to be measured during an actual parenting task.

Contrary to expectations, action readiness measured at the neurophysiological level was not related to emotion regulation in daily life. Given that there is ample research linking EEG asymmetry to self-reported and observed emotional processes (Coan & Allen, 2004), it is possible that relations were not yielded in the present study due to the long time period (eight to eighteen months) between the EEG assessment and EMA. Other studies that have shown links between lab-based physiological (including EEG asymmetry) and EMA or observational paradigms collected data much closer in time (e.g., Forbes et al., 2009; Killeen & Teti, 2012; Putnam & McSweeney, 2008; Silk et al., 2003). Although adults' resting frontal cortical asymmetry, which is associated with state-related changes in asymmetry, has shown to be highly stable for up 3 years (Allen, Urry, Hitt, & Coan, 2004; Tomarken, Davidson, Wheeler, & Kinney, 1992), it may be that *changes* in asymmetry are not as stable as during a resting state. Indeed, caring for a 6- to 8-month-old (child age at EEG assessment) presents different demands than caring for a 14- to 24-month-old (child age at EMA), and it is logical that parents would have different responses to the same child across developmental stages. For example, a mother might immediately attend to her crying 6-month-old, however, by the time this same child is 2 years old, she might hold back at first in order to promote his ability to self-soothe. Future research linking lab-based assessment of action readiness and emotional and motivational states in parents' daily lives should either conduct data collection closer in time to one another, or ideally, employ ambulatory physiological assessment measures.

Interestingly, greater EEG activity across both left and right hemispheres of the frontal cortex was related to some indices of maternal day-to-day emotion regulation. Specifically, mothers' greater bilateral activity in response to infants in distress was related to a higher proportion of adaptive coping strategies (e.g., problem solving and emotional modulation), and a lower proportion of stress responses (e.g., avoidance and wishful thinking) in parenting situations that arose naturally in daily life. This finding is consistent with recent research showing that greater activity across both hemispheres of the frontal cortex is related to cognitive stress responses and attentional control. Putnam and McSweeney (2008) showed that lower resting bilateral prefrontal activity measured in the lab was associated with greater day-to-day rumination measured via EMA, while Dennis and Solomon (2010) showed that higher bilateral frontal activity was associated with greater attentional control. These findings are consistent with previous work linking the frontal cortex to cognitive emotion regulation strategies (e.g., reappraisal), which is likely related to the prefrontal cortex's critical role in executive functioning (Ochsner & Gross, 2007). For example, a mothers' capacity to shift her attention between aspects of a challenging parenting situation has a direct impact on her ability to engage in secondary control engagement coping strategies (positive thinking, cognitive restructuring, acceptance, distraction) and inhibit stress responses (e.g., rumination), thus enabling her to focus on engaging in primary control engagement coping (e.g., problem solving, emotional modulation) to adaptively remedy a situation. That EEG measurements of bilateral frontal cortical activity, but not hemispheric asymmetry, related to self-reports of emotion regulation suggest that while hemispheric asymmetry is a useful measure for examining some components of the emotion process (action readiness specifically), understanding the physiological substrates of emotion regulation may require a broader examination of frontal activity.

Mothers' Momentary Reports of Emotion, Action Readiness, and Regulation in Daily Life

Functional emotion theory in the parenting context. This study illuminated many aspects of parental emotion in response to naturally occurring parenting situations in day-to-day life. Mothers' self-reports of momentary emotions were associated with self-reports of action readiness (i.e., "How much did you want to engage/disengage in the situation, whether or not you actually did?") in response to situations with 14- to 24-month-olds that elicited negative maternal negative emotion. For the most part, these associations were consistent with expectations according to functional emotion theory: positive emotions were related to greater readiness to approach or engage in the situation, and sadness was related to greater readiness to withdraw or disengage. Predictions for anger and worry were not supported, but the findings for each have intriguing implications for parent emotion regulation.

Although it was expected that momentary worry would be related to increased readiness to engage, it was actually related to readiness to disengage, but only for mothers who were high in intraindividual worry. Interestingly, when it came to actual behavior, mothers who were higher in momentary worry were, as predicted, more engaged. This suggests that while greater worry is related to greater actual engagement (consistent with functional emotion theory) mothers who are generally more anxious need to regulate their readiness to disengage from anxiety-provoking parenting situations. The fact that, on average, mothers *did* engage in parenting despite readiness to disengage is not surprising when considering the degree to which young children depend on their parents, particularly in situations that are challenging enough to be anxiety-provoking for adults.

Findings for anger and action readiness were intriguing, and of key importance in the application of basic emotion theory to parenting. In theory and previous research, anger has been well-established as an approach, engagement-oriented emotion (Barrett & Campos, 1987; Harmon-Jones, 2003; Harmon-Jones & Sigelman, 2001). That anger was strongly related to a readiness to disengage in the present study, suggests that it constitutes a prime example for why emotions must be studied *in context*. Previous research has shown that maternal anger is a risk factor for child abuse (Rodriguez & Green, 1997). Thus, it may be that for parents of young children, the relation between anger and disengagement is protective. Some of the mothers in this study said it best themselves: “I think you have to [disengage] in order to not take it personally and get overly frustrated about it." Another mother linked anger and disengagement more consciously to a regulatory process: "I had to pull back because I was starting to get a little angry. I don't want to be angry with him." Thus, these findings suggest that, at a very basic level, parental anger is associated with a tendency to disengage or to rapidly down-regulate engagement, perhaps to decrease the likelihood of increased anger and force toward the child.

Phenomenology of mothers’ emotion regulation in challenging parenting situations. A primary goal of the present study was to document maternal emotion regulation as it occurs in everyday life. Although emotion regulation has become a widely studied topic in the past two to three decades, methods for assessing it are constantly evolving. This study employed two ways of indexing emotion regulation via self-report, both of which suggested that regulation of action readiness, and thus behavior, is critical to parenting. First, mothers’ reports of coping strategies and stress responses identified in previous research (Responses to Stress system; Compas et al., 2001; Connor-Smith et al., 2000), suggested that when faced with a challenging parenting situation, mothers almost always use a strategy that involves adaptive engagement with the stressful situation (e.g., problem solving), negative emotions (emotion modulation and expression) or thoughts (e.g., cognitive restructuring). Notably, the proportion of action-oriented engagement strategies (problem solving, emotional modulation, emotional expression) reported in the present study was higher than in studies using the Responses to Stress system with non-parenting samples (63% in this study versus 19-49%; Andreotti et al., 2013; Compas et al., 2006; Silk et al., 2003; Wadsworth et al., 2005), which may reflect parents’ needing to manage their children’s environments and emotions due to young children’s inability to do so themselves.

The second measure of emotion regulation considered moments in which mothers either engaged in or disengaged from a parenting challenge despite a desire to do the opposite. Regulation of action readiness is relevant to parenting young children because parents must consider the needs of their children even if they do not match their own. For example, a mother who is grocery shopping when her 2-year-old son throws a tantrum in the middle of the store may feel like disengaging from the situation due to the aversive nature of the tantrum. However, she may regulate that desire (readiness) to disengage because leaving a toddler alone in this situation would be tantamount to neglect and would be counter to her goals for his safety and well-being. There are also less striking examples, given that in parenting young children, disengagement may be maladaptive even when safety is not an issue. Consider the example of the mother who is engaged in a struggle with her toddler over naptime. The mother could conceivably disengage from the situation by giving up and maybe even going to another room while her child occupied himself with toys. However, the mother’s disengaging in that moment could have downstream negative effects: the child would be exhausted due to not getting his nap, and she would be in for a long evening with a cranky toddler. Because the 3-year-old does not have the cognitive or emotional maturity to recognize the need for a nap, it is the responsibility of the parent to hold the goal for his well-being as well as her own. Thus, remaining at least somewhat engaged in a parenting situation despite readiness to disengage may have to do with the multiple goals and responsibility that parents of young children have in any given moment. The present study found that mothers followed through on a readiness to disengage in less than 5% of the over 1,000 negative emotion-eliciting parenting situations captured; in other words, they down-regulated their desire to disengage most of the time.

Interestingly, in the present study, there was no evidence for down-regulation of readiness to engage. Theoretically, parents might need to regulate a readiness to engage in a difficult parenting situation if they want to prevent themselves from using harsh discipline due to anger, or if they are trying to foster their children's self-regulation. That mothers' anger was associated with their self-reported readiness to disengage may indicate that, in the parenting context, down-regulation of the readiness to engage that is typically associated with anger happens so immediately that it is outside of awareness or not perceived to have enough of an impact on the situation for mothers to have reported it.

In sum, both measures of emotion regulation suggested that mothering young children requires a high degree of engagement in situations related to children's well-being, and thus regulation of action readiness, particularly down-regulation of disengagement, is important to consider.

Impact of specific emotions on emotion regulation. Predictions about the systematic relations between specific emotions and emotion regulation also gained some support in the present study. Generally, higher levels of positive emotions (both in general and in the moment of a challenging parenting situation) were related to more adaptive regulatory strategies, including greater regulation of the desire to disengage and a higher proportion of adaptive coping strategies than maladaptive stress responses. Higher levels of negative emotions, on the other hand, were related to emotional dysregulation, including less regulation of the desire to disengage and a lower proportion of coping strategies to stress responses.

Contrary to prediction, higher levels of sadness were related to higher proportions of stress responses characterized by engagement with the stressor, such as rumination and impulsive behavior. It had been predicted that higher levels of sadness would be related to lower proportions of engagement stress responses and higher proportions of those characterized by disengagement (e.g., avoidance) due to sadness being associated with readiness to withdraw/disengage. Yet, this finding is consistent with the linkages between depression and cognitive engagement with a stressor (i.e., rumination; see Aldao, Nolen-Hoeksema, & Schweizer, 2010, for a meta-analysis), and suggests that in the case of depression and sadness, it may be useful to distinguish between behavioral and cognitive engagement. It is notable that many of the stress responses subsumed under the engagement stress responses category used in the present study indicate *cognitive* engagement (rumination, anticipatory worry). In this study, then, sadness was associated with higher levels of cognitive engagement with a stressor, but lower levels of behavioral engagement. These findings are consistent with the idea that disengaging completely from a stressor may be particularly difficult in parenting given the dependency of young children on their caregivers.

The multilevel nature of the EMA data allowed for examination of the manner in which emotion regulation in daily life was related to situationally-specific versus more general, "trait-like" emotional responding (intraindividual averages of a specific emotion across all parenting situations). The degree to which mothers regulated the desire to disengage was more frequently associated with general, trait-like intraindividual measures of positive emotion and irritation than with emotions experienced in the same moment as the challenge. The proportion of specific coping strategies to stress responses, however, was associated with in-the-moment *and* general positive and negative emotions. These findings highlight the ways in which repeated measurement of emotion and regulation, as well as a multilevel analytic approach, further our understanding of emotional processes (Bolger et al., 2003; Ram et al., 2013; Ram & Gerstorf, 2009). For example, these findings suggest that enhancing positive emotion in general is important for the development of the ability to regulate disengagement, but that in order to reduce maladaptive responses, it may be important to gear interventions toward the moment of stress.

The finding that higher levels of positive emotions were associated with more regulation of disengagement and a higher proportion of coping strategies to stress responses is consistent with the broaden-and-build theory of positive emotion (Fredrickson, 1998; 2001), which posits that positive emotions increase individuals' ability to gather and flexibly use resources and skills that enable them to cope in times of stress, and that positive emotion "undoes" negative emotion. It also identifies a possible mechanism for the well-documented finding that warm parent-child relationships foster effective parenting and child outcomes (i.e., Hood & Eyberg, 2010). Specifically, experiencing positive emotions with children may enable parents to develop skills that help them cope effectively with their own negative emotions when challenging moments with their children inevitably arise. This process may operate at the level of the dyad, as well, in that parents and children who experience positive emotions together may develop ways of working together that enable children to be more easily soothed or redirected in difficult situations. Consistent with this notion, previous research indicates that parents with depression (and thus presumably a lower capacity to regulate adaptively) have difficulties repairing disruptions with their children (Jameson, Gelfand, Kulcscar, & Teti, 1997), while mothers who show high levels of parenting sensitivity (and thus presumably more adaptive emotion regulation) show increased dyadic physiological regulation in the context of an interpersonal stressor (Moore, Hill-Soderlund, Propper, Calkins, Mills-Koonce, & Cox, 2009). The present study suggests that a future avenue for research may be to look at how positive parent-child relationships enhance regulatory processes within parents as well as dyads.

Limitations

There were several limitations of the present study that warrant consideration. First, participants were recruited from the community, and standardized measures of psychiatric symptoms (not used in the present analyses) indicated that the sample was largely non-distressed. While the field can certainly benefit from a greater understanding of parent emotional processes in typically developing families, replication of findings in clinical samples is needed before findings can inform intervention.

Additionally, the findings must be considered in light of several procedural limitations.

EEG. Given that behavior, particularly helping behavior, was a key constructs in this study, the fact that mothers were seated alone in a laboratory, wearing an electrode net, and asked to stay as still as possible during one of the assessments of action readiness is a limitation. Additionally, mothers were not actually witnessing their infants' real-time distress; they knew that the distress they were seeing was over, and they were not in close physical proximity to their children. Although previous work shows that shifts in mothers' EEG-measured action readiness in response to videos of their infants' distress was related to observed sensitive parenting (Killeen & Teti, 2012), the degree to which this task could elicit action readiness associated with approach-oriented helping behavior in day-to-day life several months later is unclear. Future studies of parental emotion could benefit from the growing field of ambulatory physiological assessment in order to assess physiological action readiness in the moment of actual parenting (Wilhelm & Grossman, 2010).

EMA. Despite the many benefits of EMA in regard to ecological validity, increased reliability due to repeated measurements, and lessening recall bias, one drawback of the method as employed in this study was reliance on self-report. Although self-report is useful in understanding mothers' subjective experiences and behavior, it requires mothers to be keenly aware of their emotional states. Paradoxically, the field would likely benefit most from a better understanding of those mothers who are less aware of their emotions, particularly given the relations between alexithymia and lower empathic responding (Feldman-Hall, Dalgleish, & Mobbs, 2013) as well as poorer emotion regulation (Chen, Xu, Jing, & Chan, 2011). This study attempted to reconcile this limitation by using EMA alongside a physiological laboratory task, but predicted linkages between assessments were not found, perhaps due to methodological flaws. Employing ambulatory physiological assessment is also a potential solution for this problem.

Given the documented importance of situational demands on parenting (Miller, Shim & Holden, 1998), another limitation of this particular analysis is the exclusion of potentially important situational factors in predicting mothers' emotion regulation. In explaining their feelings, thoughts, and actions, mothers also spontaneously provided information about whether or not they were receiving help, whether they were dealing with multiple demands at once (e.g., a temper tantrum while on a work-related phone call while also trying to empty the dishwasher), whether someone in the family was sick, or whether they had had an argument with their spouse, to name just a few. There can be little doubt that these situational forces have an impact on mothers' thoughts, feelings, and behaviors. Future analyses with these data will address this possibility. Finally, this work is based on the premise that parents' effective emotion regulation should facilitate effective parenting, but does not assess parenting itself. Future work should integrate mothers' EMA reports with observation of parenting behaviors.

Integration of EEG and EMA. In addition to the drawback of the 6- to 18-month time-lag between EEG and EMA data collections, there are conceptual challenges in the integration of these two methods. Both EEG and EMA are useful to the study of emotion because they capture affective processes as they unfold over time; however, they do this on very different time scales. While EEG captures emotional responding to a stimulus that happens so quickly that it may be partly or wholly outside of awareness, EMA provides information about the way in which individuals' conscious experiences of emotion unfold over minutes, hours, or days. It could be argued that action readiness measured at the neurophysiological level within seconds of a stimulus is quite different than a mother's conscious desire to engage or disengage. On the other hand, EEG-measured action readiness in response to evocative stimuli has been shown to be related to self-reported emotions and behavior in other research (e.g., Harmon-Jones et al., 2003), and bilateral frontal activity was related to self-reported coping strategies in the present study. Still, it would be worthwhile for future research to examine action readiness at the neurophysiological level over longer periods of time or, optimally, to be collected in an ambulatory fashion so that dynamic changes in responding could be assessed over time as individuals go about their daily lives.

Conclusions

In spite of limitations, this study contributes new knowledge to the field of parent emotion by delineating a fine-grained picture of how parents experience and regulate emotion in the context of a relationship in which they are responsible for their own well-being, as well as that of their young child. Application of functional emotion theory to real-world parenting provided support to the assertion that emotion and its regulation must be considered *in context* (Cole et al., 1994; Compas et al., 2001; Gross & Thompson, 2007). While some expressed emotions were related to action readiness in line with functional emotion theory, others showed different patterns. Specifically, anger was related to greater self-reported readiness to disengage, suggesting a possible protective mechanism to buffer against harsh discipline. Phenomenological aspects of parents' emotion regulation in response to challenging situations with their children were documented, and indicated the centrality of regulating action readiness and thus behavior in parenting young children. Additionally, a new method of assessing maternal momentary regulation was developed and validated, and multiple predictors of emotion regulation in the face of parenting challenges were identified, including a laboratory-based measure of brain activity. Particularly illuminating was the influence of positive emotion on enhanced regulation of negative emotion during challenging parenting situations. Further pursuit of this type of work has the potential to uncover further predictors of adaptive parent emotion regulation and to inform prevention and intervention strategies for families in need.

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Appendix A: Tables

Table 1

Latent Class Analysis Model Comparison

Number of Classes in Model	AIC[a]	BIC (Sample size adjusted)	Entropy[b]	Lo-Mendell-Rubin Adjusted LRT Test
3	12492.18	12581.15 (12523.98)	0.86	540.97, $p < .01$
4	12120.77	12234.47 (12161.41)	0.92	370.72, $p < .01$
5	11651.77	11790.18 (11701.25)	0.96	465.59, $p < .01$
6	11549.84	11712.97 (11608.15)	.096	-908.86, $p > .10$

[a]Lower AIC and SS Adj. BIC values indicate better fit.

[b]Entropy should be greater than 0.7. Values closer to 1 are better.

Table 2
Descriptive Statistics for Second-by-second EEG Asymmetry

Infant Video Condition	First Infant Distress Video Presentation: Mean	SD	Minimum	Maximum		Average of all Infant Distress Video Presentations: Mean	SD	Minimum	Maximum
Second 1	-0.12	0.48	-2.52	1.27	Mid-Frontal (F4F3) Asymmetry	-0.03	0.48	-1.40	3.34
Second 2	-0.07	0.88	-7.35	3.44		-0.09	0.46	-2.72	1.25
Second 3	0.03	0.36	-1.48	1.83		-0.01	0.28	-1.17	1.48
Second 4	-0.04	0.33	-1.42	1.31		-0.04	0.26	-1.05	0.85
Second 5	-0.05	0.25	-0.89	0.59		-0.02	0.25	-1.37	0.59
Second 6	-0.02	0.26	-1.45	0.50		-0.03	0.18	-0.71	0.45
Second 7	0.00	0.27	-0.49	0.88		0.01	0.22	-0.56	1.07
Second 8	-0.07	0.39	-2.10	1.16		-0.03	0.21	-0.61	0.79
Second 9	-0.04	0.28	-1.04	0.83		-0.04	0.24	-1.17	1.15
Second 10	-0.04	0.29	-0.88	1.28		-0.02	0.23	-0.83	0.91
Second 1	-0.23	0.93	-6.15	0.88	Lateral Frontal (F8F7) Asymmetry	-0.12	0.42	-2.53	0.51
Second 2	-0.09	0.41	-2.02	1.27		-0.10	0.32	-1.46	0.81
Second 3	-0.02	0.34	-1.61	1.01		-0.03	0.35	-0.91	2.28
Second 4	-0.04	0.49	-1.23	3.55		-0.08	0.48	-1.63	3.38
Second 5	-0.11	0.32	-1.25	0.70		-0.08	0.28	-1.57	0.41
Second 6	-0.10	0.28	-1.12	0.52		-0.09	0.22	-0.81	0.34
Second 7	-0.03	0.28	-0.87	0.90		-0.06	0.21	-0.77	0.85
Second 8	-0.12	0.47	-1.88	1.76		-0.07	0.22	-0.96	0.76
Second 9	-0.09	0.45	-3.78	1.42		-0.08	0.24	-1.35	0.74
Second 10	-0.11	0.31	-1.36	0.76		-0.08	0.21	-0.81	0.40

Table 3

Descriptive Statistics for Second-by-second EEG Mid-Frontal Alpha Power

	First Infant Distress Video Presentation					Average of all Infant Distress Video Presentations			
Infant Video Condition	Mean	SD	Minimum	Maximum		Mean	SD	Minimum	Maximum
Second 1	0.56	0.58	0.06	3.13	Mid-Frontal Right-Hemisphere (F4) Alpha Power	0.69	0.80	0.10	6.90
Second 2	0.56	0.76	0.04	4.84		0.54	0.56	0.08	4.08
Second 3	0.52	0.67	0.06	5.17		0.52	0.49	0.10	2.77
Second 4	0.44	0.44	0.07	2.85		0.50	0.43	0.12	2.74
Second 5	0.39	0.29	0.06	1.52		0.51	0.45	0.10	2.96
Second 6	0.45	0.46	0.07	3.11		0.46	0.36	0.09	2.17
Second 7	0.45	0.45	0.05	2.36		0.52	0.55	0.07	3.52
Second 8	0.47	0.47	0.05	2.56		0.49	0.42	0.08	2.42
Second 9	0.44	0.44	0.05	2.53		0.47	0.46	0.08	3.62
Second 10	0.43	0.39	0.08	2.04		0.51	0.42	0.10	2.75
Second 1	0.68	0.77	0.10	4.70	Mid-Frontal Left-Hemisphere (F3) Alpha Power	0.72	0.62	0.18	3.56
Second 2	0.62	1.26	0.08	11.61		0.63	0.68	0.09	4.42
Second 3	0.49	0.48	0.08	3.35		0.54	0.46	0.10	2.58
Second 4	0.49	0.52	0.07	2.66		0.54	0.43	0.11	2.45
Second 5	0.44	0.38	0.04	2.01		0.53	0.45	0.09	2.86
Second 6	0.46	0.43	0.08	2.77		0.49	0.34	0.12	1.99
Second 7	0.45	0.34	0.08	1.92		0.51	0.41	0.12	2.69
Second 8	0.54	0.67	0.04	4.50		0.52	0.44	0.12	2.47
Second 9	0.48	0.50	0.06	3.22		0.51	0.42	0.10	2.46
Second 10	0.48	0.39	0.08	1.76		0.53	0.40	0.10	2.02

Table 4

Descriptive Statistics for Second-by-second EEG Lateral-Frontal Alpha Power

Infant Video Condition	First Infant Distress Video Presentation: Mean	SD	Minimum	Maximum		Average of all Infant Distress Video Presentations: Mean	SD	Minimum	Maximum
Second 1	0.59	0.47	0.10	2.50	Lateral-Frontal Right-Hemisphere (F8) Alpha Power	0.20	5.79	0.72	0.67
Second 2	0.54	0.62	0.07	3.60		0.11	3.84	0.55	0.51
Second 3	0.55	0.59	0.08	3.55		0.13	3.21	0.56	0.52
Second 4	0.48	0.59	0.08	4.29		0.10	4.28	0.54	0.54
Second 5	0.41	0.41	0.09	3.24		0.09	3.00	0.51	0.45
Second 6	0.46	0.47	0.08	2.86		0.11	1.76	0.46	0.29
Second 7	0.44	0.42	0.08	2.09		0.12	3.04	0.49	0.42
Second 8	0.48	0.47	0.06	2.54		0.11	2.06	0.48	0.35
Second 9	0.47	0.52	0.07	3.29		0.12	1.98	0.47	0.37
Second 10	0.44	0.33	0.10	1.78		0.10	2.18	0.51	0.37
Second 1	0.83	1.18	0.11	7.80	Lateral-Frontal Left-Hemisphere (F7) Alpha Power	0.84	0.77	0.18	5.49
Second 2	0.63	0.68	0.08	4.06		0.65	0.57	0.11	3.71
Second 3	0.57	0.65	0.08	4.79		0.59	0.50	0.12	3.05
Second 4	0.52	0.45	0.09	2.47		0.61	0.54	0.13	3.29
Second 5	0.52	0.48	0.09	2.55		0.60	0.54	0.15	3.57
Second 6	0.56	0.56	0.08	3.15		0.55	0.35	0.14	1.79
Second 7	0.47	0.37	0.08	2.52		0.56	0.40	0.14	2.19
Second 8	0.60	0.65	0.08	3.13		0.55	0.43	0.16	3.02
Second 9	0.56	0.79	0.11	7.08		0.55	0.47	0.11	3.31
Second 10	0.55	0.48	0.10	2.40		0.59	0.43	0.13	2.43

Table 5

Descriptive Statistics for EEG Alpha Power and Asymmetry Variables, Averaged for Baseline and Infant Distress Conditions

Infant Video Condition	Mean	SD	Minimum	Maximum
Baseline F4	1.43	2.52	0.09	23.85
Baseline F3	1.47	2.67	0.11	25.70
Baseline F4F3	-0.04	0.37	-1.85	1.58
Baseline F8	1.70	3.96	0.15	33.84
Baseline F7	1.59	3.76	0.19	36.56
Baseline F8F7	0.11	3.81	-17.36	32.25
1st Distress F4	0.47	0.40	0.08	2.24
1st Distress F3	0.51	0.44	0.11	2.52
1st Distress F4F3	-0.04	0.23	-1.46	0.60
1st Distress F8	0.49	0.39	0.12	2.22
1st Distress F7	0.58	0.48	0.15	2.80
1st Distress F8F7	-0.09	0.25	-0.95	0.61
Averaged Distress F4	0.52	0.44	0.09	3.04
Averaged Distress F3	0.55	0.41	0.13	2.20
Averaged Distress F4F3	-0.03	0.22	-0.85	0.84
Averaged Distress F8	0.53	0.39	0.15	2.78
Averaged Distress F7	0.61	0.44	0.17	2.75
Averaged Distress F8F7	-0.08	0.21	-0.79	0.45

Table 6

Descriptive Statistics for Ecological Momentary Assessment Emotion, Action Readiness, Actual Engagement/Disengagement, and Regulation Variables

						Intraindividual Data			
	n	*M*	*SD*	Range	Skew	Range	Mean (Range)	SD (Range)	ICC
Emotions									
Happiness	1769	3.10	1.48	0–5	-.78	11-57	3.15 (1.90–4.24)	1.37 (.70-2.06)	.10
Confidence	1769	3.11	1.35	0–5	-.66	11-57	3.13 (1.72–5.00)	1.15 (.00-2.15)	.26
Contentment	1769	3.06	1.54	0–5	-.67	11-57	3.11 (1.60–4.21)	1.39 (.48-2.05)	.14
Pleasure	1769	2.78	1.70	0–5	-.45	11-57	2.83 (1.50–4.00)	1.56 (.75-2.35)	.12
Sadness	1770	0.73	1.15	0–5	1.54	11-57	.73 (.06–2.10)	.1.06 (.24-2.02)	.08
Irritated/Angry	1770	0.63	1.12	0–5	1.88	11-57	.60 (.00–2.00)	1.02 (.25-2.10)	.09
Concerned/Worried	1770	0.69	1.10	0–5	1.68	11-57	.71 (.00–3.10)	.95 (0-1.74)	.18
Behavioral Engagement/ Disengagement									
Actual Disengagement	1036	0.81	1.24	0–5	1.51	4-45	.73 (.00–2.00)	1.00 (.00-2.00)	.14
Desired Disengagement	1036	1.84	1.69	0–5	.33	4-45	1.84 (.00–3.00)	1.53 (.00-3.00)	.15
Actual Engagement	1036	3.89	1.08	0–5	-1.13	4-45	3.95 (2.00-5.00)	.93 (.00-2.00)	.23
Desired Engagement	1035	3.12	1.45	0–5	-.57	4-45	3.13 (1.00-5.00)	1.20 (.00-3.00)	.21
Regulation									
Regulation of Disengagement	519	2.45	.65	1-3	-.76	1-27	2.49 (1.00-3.00)	.51 (.00-1.15)	.07
Coping Strategies Proportions	981	.79	.27	0-1	-1.22	2-44	.80 (.43-1.00)	.24 (.00-.42)	.13
Primary Control Engagement	981	.63	.32	0-1	-.48	2-44	.63 (.24-.85)	.39 (.00-.71)	.06
Secondary Control Engagement	981	.16	.27	0-1	1.77	2-44	.15 (.00-.36)	.23 (.00-.44)	.06
Stress Responses Proportions	981	.21	.27	0-1	1.22	2-44	.20 (.00-.57)	.24 (.00-.42)	.13
Involuntary Engagement	981	.13	.23	0-1	1.86	2-44	.12 (.00-.30)	.19 (.00-.41)	.07
Voluntary Disengagement	981	.08	.19	0-1	2.90	2-44	.08 (.00-.43)	.19 (.00-.58)	.10
Involuntary Disengagement	981	.003	.05	0-1	18.61	2-44	.002 (.00-.05)	.01 (.00-.26)	<.01

Table 7

Correlations Among Momentary Emotion, Action Readiness, Actual Engagement/Disengagement, and Regulation Variables

	Happy	Conf-ident	Content	Pleased	Sad	Irritated	Worried	Actual Diseng.	Desired Diseng.	Actual Eng.	Desired Eng.	Reg. of Diseng.	Coping Strat-egies	Invol. Eng.
Happy	1													
Confident	.68*	1												
Content	.85*	.75*	1											
Pleased	.86*	.72*	.86*	1										
Sad	-.66*	-.50*	-.67*	-.63*	1									
Irritated	-.55*	-.47*	-.58*	-.57*	.55*	1								
Concerned	-.43*	-.38*	-.46*	-.41*	.52*	.36*	1							
Actual Disengagement	-.14*	-.17*	-.17*	-.16*	.15*	.19*	-.04	1						
Desired Disengagement	-.31*	-.35*	-.37*	-.37*	.32*	.43*	.09*	.53*	1**					
Actual Engagement	.03	.13*	.04	.02	.02	.03	.10*	-.50*	-.25*	1				
Desired Engagement	.29*	.36*	.33*	.32*	-.21*	-.31*	-.02	-.38*	-.69*	.44*	1			
Reg. of Disengagement	.01	.001	.01	.02	.002	-.03	.07+	-.93*	-.14*	.42*	.03	1		
Coping Strategies	.06*	.13*	.11*	.08*	-.08*	-.22*	-.06*	-.20*	-.23*	.10*	.17*	.16*	1	
Involuntary Engagement	-.12**	-.15*	-.15*	-.11*	.15*	.23*	.12*	.15*	.17*	-.05	-.11*	-.09+	-.72*	1
Voluntary Disengagement	.06+	-.002	.04	.03	-.06*	.03	-.06+	.09*	.10*	-.05+	-.10*	-.09*	-.55*	-.16*

* $p < .05$;   + $p < .10$

Table 8

Correlations Among Intraindividual Emotion, Action Readiness, Actual Engagement/Disengagement, and Regulation Variables

	Happy	Conf-ident	Content	Pleased	Sad	Irritated	Worried	Actual Diseng.	Desired Diseng.	Actual Eng.	Desired Eng.	Reg. of Diseng.	Coping Strat-egies	Invol. Eng.
Happy	1													
Confident	.67*	1												
Content	.87*	.82*	1											
Pleased	.88*	.80*	.92*	1										
Sad	-.55*	-.49*	-.60*	-.56*	1									
Irritated	-.34*	-.25+	-.37*	-.36*	.42*	1								
Concerned	-.41*	-.48*	-.52*	-.48*	.66*	.32*	1							
Actual Disengagement	-.29*	-.12	-.25+	-.22	.18	.38*	.08	1						
Desired Disengagement	-.11	-.15	-.16	-.13	-.23+	.28*	.21	.62*	1					
Actual Engagement	-.25+	.37*	.31*	.21	.004	-.01	.05	-.50*	-.29*	1				
Desired Engagement	.20	.19	.22	.13	-.01	-.05	-.004	-.42*	-.61*	.51*	1			
Reg. of Disengagement	.08	-.09	.03	.04	-.03	-.20	.08	-.56*	-.15	.29*	-.03	1		
Coping Strategies	-.10	.16	.11	-.01	-.10	-.25+	-.08	-.11	-.22	.06	.15	-.13	1	
Involuntary Engagement	-.16	-.28*	-.32*	-.22	.34*	.39*	.23+	.28*	.23	-.15	-.04	-.04	-.74*	1
Voluntary Disengagement	.32*	.05	.16	.24+	-.17	-.01	-.09	-.14	.10	.11	-.15	-.24+	-.75*	.12

Table 9

Relations Between Happiness, Action Readiness, and Actual Engagement and Disengagement

	Actual Disengagement	Desired Disengagement	Actual Engagement	Desired Engagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Happiness: Fixed Effects				
Intercept, γ_{00}	.66* (.08)	1.55* (.10)	3.95* (.08)	3.33* (.09)
Momentary Emotion, γ_{10}	-.10* (.03)	-.37* (.04)	-.002 (.03)	.29* (.04)
Intraindividual Emo., γ_{01}	-.37* (.14)	-.32† (.19)	.30† (.15)	.32† (.17)
Moment*Intraind., γ_{11}	-.06 (.05)	-.09 (.07)	.06 (.05)	.07 (.07)
Happiness: Random Effects				
Variance intercept, σ^2_{u0}	.21	.41	.29	.34
Variance slope, σ^2_{u1}	.01	.01	.01	.03
Correlation, r_{u0u1}	.40	-.31	.36	-.32
Residual variance, σ^2_e	1.27	2.09	.88	1.47
AIC	3300.38	3820.11	2953.77	3479.17

Note: Estimates are based on multilevel models of 1035-1036 observations from 55 participants.
* $p < .05$; † $p < .10$

Table 10

Relations Between Happiness and Regulation

	Regulation of Disengagement	Coping Strategies Total	Involuntary Engagement	Voluntary Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Happiness: Fixed Effects				
Intercept, γ_{00}	2.52* (.05)	.80* (.02)	.11* (.01)	
Momentary Emotion, γ_{10}	.02 (.03)	.01* (.01)	-.01* (.01)	
Intraindividual Emo., γ_{01}	.17† (.09)	-.03 (.03)	-.02 (.02)	
Moment*Intraind., γ_{11}	.07 (.05)	-.01 (.01)	.01 (.01)	
Happiness: Random Effects				
Variance intercept, σ^2_{u0}	.04	.01	.00	Model did not
Variance slope, σ^2_{u1}	.01	.00	.00	converge
Correlation, r^2_{u0u1}	.63	.35	.23	
Residual variance, σ^2_e	.37	.06	.05	
AIC	1037.63	206.20	-137.32	

Note: Estimates are based on multilevel models of 981 observations from 55 participants for all except Regulation of Disengagement, for which estimates are based on multilevel models of 519 observations from 53 participants.
* $p < .05$; † $p < .10$

Table 11

Relations Between Confidence, Action Readiness, and Actual Engagement and Disengagement

	Actual Disengagement	Desired Disengagement	Actual Engagement	Desired Engagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Confidence: Fixed Effects				
Intercept, γ_{00}	.66* (.08)	1.58* (.10)	3.95* (.08)	
Momentary Emotion, γ_{10}	-.17* (.04)	-.48* (.04)	.02 (.04)	
Intraindividual Emo., γ_{01}	-.22* (.11)	-.34* (.13)	.31* (.11)	
Moment*Intraind., γ_{11}	-.12* (.05)	-.15* (.06)	-.03 (.05)	
Confidence: Random Effects				
Variance intercept, σ^2_{u0}	.23	.37	.36	Model did not converge
Variance slope, σ^2_{u1}	.01	.02	.03	
Correlation, r^2_{u0u1}	.34	-.46	-.23	
Residual variance, σ^2_e	1.25	2.04	1.42	
AIC	3287.61	3792.37	3450.64	

Note: Estimates are based on multilevel models of 1035-1036 observations from 55 participants.
* $p < .05$; † $p < .10$

Table 12

Relations Between Confidence and Regulation

	Regulation of Disengagement	Coping Strategies Total	Involuntary Engagement	Voluntary Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Confidence: Fixed Effects				
Intercept, γ_{00}	2.50* (.05)	.81* (.02)		.08* (.01)
Momentary Emotion, γ_{10}	.02 (.03)	.02* (.01)		-.001 (.01)
Intraindividual Emo., γ_{01}	.05 (.07)	.03 (.02)		.01 (.02)
Moment*Intraind., γ_{11}	.05 (.04)	.001 (.01)		.00 (.01)
Confidence: Random Effects				
Variance intercept, σ^2_{u0}	.06	.01	Model did not converge	.004
Variance slope, σ^2_{u1}	.01	.00		.00
Correlation, r^2_{u0u1}	.96	.44		.11
Residual variance, σ^2_e	.37	.06		.03
AIC	1031.31	201.84		-497.09

Note: Estimates are based on multilevel models of 981 observations from 55 participants for all except Regulation of Disengagement, for which estimates are based on multilevel models of 519 observations from 53 participants.
* $p < .05$; † $p < .10$

Table 13

Relations Between Contentment, Action Readiness, and Actual Engagement and Disengagement

	Actual Disengagement	Desired Disengagement	Actual Engagement	Desired Engagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Contentment: Fixed Effects				
Intercept, γ_{00}	.66* (.07)	1.52* (.10)	3.94* (.08)	3.34* (.09)
Momentary Emotion, γ_{10}	-.12* (.03)	-.41* (.04)	-.01 (.03)	.30* (.04)
Intraindividual Emo., γ_{01}	-.31* (.12)	-.39* (.15)	.34* (.13)	.33* (.15)
Moment*Intraind., γ_{11}	-.05 (.05)	-.05 (.06)	.06 (.05)	.03 (.06)
Contentment: Random Effects				
Variance intercept, σ^2_{u0}	.19	.35	.28	.35
Variance slope, σ^2_{u1}	.02	.02	.02	.03
Correlation, r^2_{u0u1}	.04	-.72	.43	-.23
Residual variance, σ^2_e	1.25	1.99	.86	1.42
AIC	3287.43	3772.67	2938.93	3450.62

Note: Estimates are based on multilevel models of 1035-1036 observations from 55 participants.
* $p < .05$; † $p < .10$

Table 14

Relations Between Contentment and Regulation

	Regulation of Disengagement	Coping Strategies Total	Involuntary Engagement	Voluntary Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Contentment: Fixed Effects				
Intercept, γ_{00}	2.51* (.05)	.80* (.02)	.11* (.01)	.09* (.01)
Momentary Emotion, γ_{10}	.01 (.03)	.02* (.01)	-.01* (.01)	.002 (.01)
Intraindividual Emo., γ_{01}	.13 (.07)	.01 (.03)	-.03+ (.02)	.02 (.02)
Moment*Intraind., γ_{11}	.06 (.04)	-.01 (.01)	.01 (.01)	-.002 (.01)
Contentment: Random Effects				
Variance intercept, σ^2_{u0}	.04	.01	.003	.01
Variance slope, σ^2_{u1}	.01	.00	.001	.00
Correlation, r^2_{u0u1}	.60	.63	.19	.89
Residual variance, σ^2_e	.38	.06	.05	.03
AIC	1038.80	199.86	-147.25	-504.71

Note: Estimates are based on multilevel models of 981 observations from 55 participants for all except Regulation of Disengagement, for which estimates are based on multilevel models of 519 observations from 53 participants. * $p < .05$; † $p < .10$

Table 15

Relations Between Pleasure, Action Readiness, and Actual Engagement and Disengagement

	Actual Disengagement	Desired Disengagement	Actual Engagement	Desired Engagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Pleasure: Fixed Effects				
Intercept, γ_{00}	.64* (.08)	1.48* (.10)	3.95* (.09)	3.38* (.10)
Momentary Emotion, γ_{10}	-.11* (.03)	-.39* (.03)	-.01 (.03)	.29* (.03)
Intraindividual Emo., γ_{01}	-.26* (.12)	-.32+ (.16)	.20 (.13)	.24 (.15)
Moment*Intraind., γ_{11}	-.01 (.05)	-.001 (.05)	-.02 (.04)	.04 (.05)
Pleasure: Random Effects				
Variance intercept, σ^2_{u0}	.21	.40	.32	.39
Variance slope, σ^2_{u1}	.01	.01	.01	.01
Correlation, r^2_{u0u1}	.32	-.45	.66	-.38
Residual variance, σ^2_e	1.26	1.96	.88	1.44
AIC	3293.10	3761.79	2952.53	3452.43

Note: Estimates are based on multilevel models of 1035-1036 observations from 55 participants.
* $p < .05$; † $p < .10$

Table 16

Relations Between Pleasure and Regulation

	Regulation of Disengagement	Coping Strategies Total	Involuntary Engagement	Voluntary Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Pleasure: Fixed Effects				
Intercept, γ_{00}	2.55* (.06)	.80* (.02)	.11* (.02)	.09* (.01)
Momentary Emotion, γ_{10}	.03 (.03)	.01 (.01)	-.01* (.01)	.003 (.004)
Intraindividual Emo., γ_{01}	.16† (.08)	-.02 (.03)	-.01 (.02)	.04+ (.02)
Moment*Intraind., γ_{11}	.07 (.04)	-.02+ (.01)	.02+ (.01)	.01 (.01)
Pleasure: Random Effects				
Variance intercept, σ^2_{u0}	.05	.01	.004	.01
Variance slope, σ^2_{u1}	.01	.00	.00	.00
Correlation, r^2_{u0u1}	.75	.28	.18	.81
Residual variance, σ^2_e	.37	.06	.05	.03
AIC	1037.56	201.35	-134.14	-500.88

Note: Estimates are based on multilevel models of 981 observations from 55 participants for all except Regulation of Disengagement, for which estimates are based on multilevel models of 519 observations from 53 participants. * $p < .05$; † $p < .10$

Table 17

Relations Between Overall Positive Emotion, Action Readiness, and Actual Engagement and Disengagement

	Actual Disengagement	Desired Disengagement	Actual Engagement	Desired Engagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Positive Emotion: Fixed Effects				
Intercept, γ_{00}	.65* (.08)	1.49* (.10)	3.92* (.08)	3.37* (.09)
Momentary Emotion, γ_{10}	-.15* (.04)	-.51* (.04)	-.01 (.03)	.39* (.04)
Intraindividual Emo., γ_{01}	-.36* (.13)	-.45* (.17)	.35* (.14)	.40* (.16)
Moment*Intraind., γ_{11}	-.09 (.06)	-.09 (.07)	.04 (.05)	.08 (.07)
Positive Emotion: Random Effects				
Variance intercept, σ^2_{u0}	.20	.37	.29	.36
Variance slope, σ^2_{u1}	.02	.02	.02	.03
Correlation, r^2_{u0u1}	.21	-.60	.50	-.28
Residual variance, σ^2_{e}	1.25	1.94	.87	1.39
AIC	3286.19	3745.23	2944.44	3424.11

Note: Estimates are based on multilevel models of 1035-1036 observations from 55 participants.
* $p < .05$; † $p < .10$

Table 18

Relations Between Overall Positive Emotion and Regulation

	Regulation of Disengagement	Coping Strategies Total	Involuntary Engagement	Voluntary Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Positive Emotion: Fixed Effects				
Intercept, γ_{00}	2.51* (.05)	.80* (.02)	.11* (.01)	.09* (.01)
Momentary Emotion, γ_{10}	.02 (.03)	.02* (.01)	-.02* (.01)	.003 (.01)
Intraindividual Emo., γ_{01}	.16† (.09)	.003 (.03)	-.03 (.02)	.03 (.02)
Moment*Intraind., γ_{11}	.10† (.05)	-.02 (.01)	.02 (.01)	-.001 (.01)
Positive Emotion: Random Effects				
Variance intercept, σ^2_{u0}	.05	.01	.004	.01
Variance slope, σ^2_{u1}	.01	.001	.001	.00
Correlation, r^2_{u0u1}	.71	.42	.25	.72
Residual variance, σ^2_{e}	.37	.06	.05	.03
AIC	1033.68	197.78	-146.32	-502.21

Note: Estimates are based on multilevel models of 981 observations from 55 participants for all except Regulation of Disengagement, for which estimates are based on multilevel models of 519 observations from 53 participants. * $p < .05$; † $p < .10$

Table 19

Relations Between Sadness, Action Readiness, and Actual and Disengagement

	Actual Disengagement	Desired Disengagement	Actual Engagement	Desired Engagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Sadness: Fixed Effects				
Intercept, γ_{00}	.67* (.07)	1.62*	3.93* (.08)	3.23* (.10)
Momentary Emotion, γ_{10}	.17* (.03)	.38*	.01 (.03)	-.21* (.05)
Intraindividual Emo., γ_{01}	.37* (.18)	.49†	-.11 (.21)	-.15 (.25)
Moment*Intraind., γ_{11}	-.23* (.08)	.13	.11 (.08)	-.15 (.12)
Sadness: Random Effects				
Variance intercept, σ^2_{u0}	.20	.41	.31	.44
Variance slope, σ^2_{u1}	.003	.00	.01	.05
Correlation, r^2_{u0u1}	.05	.001	-.53	.05
Residual variance, σ^2_e	1.27	2.13	.89	1.51
AIC	3290.42	3826.30	2955.81	3514.91

Note: Estimates are based on multilevel models of 1035-1036 observations from 55 participants.
* $p < .05$; † $p < .10$

Table 20

Relations Between Sadness and Regulation

	Regulation of Disengagement	Coping Strategies Total	Involuntary Engagement	Voluntary Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Sadness: Fixed Effects				
Intercept, γ_{00}		.80* (.02)	.11* (.01)	.09* (.01)
Momentary Emotion, γ_{10}	Did not	-.01 (.01)	.01+ (.01)	-.01 (01)
Intraindividual Emo., γ_{01}	converge	-.03 (.04)	.06* (.03)	-.03 (.03)
Moment*Intraind., γ_{11}		-.02 (.02)	.02 (.02)	00 (.01)
Sadness: Random Effects				
Variance intercept, σ^2_{u0}		.01	.00	.00
Variance slope, σ^2_{u1}		.00	.00	.00
Correlation, r^2_{u0u1}		-.23	.22	.00
Residual variance, σ^2_e		.06	.05	.00
AIC		203.71	-141.73	-500.32

Note: Estimates are based on multilevel models of 981 observations from 55 participants for all except Regulation of Disengagement, for which estimates are based on multilevel models of 519 observations from 53 participants.
* $p < .05$; † $p < .10$

Table 21

Relations Between Irritation/Anger, Action Readiness, and Actual Engagement and Disengagement

	Desired Engagement	Actual Engagement	Desired Disengagement	Actual Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Irritation/Anger: Fixed Effects				
Intercept, γ_{00}	3.27* (.10)	3.92* (.08)	1.57* (.09)	.68* (.07)
Momentary Emotion, γ_{10}	-.31* (.05)	.02 (.03)	.52* (.05)	.16* (.04)
Intraindividual Emo., γ_{01}	-.19 (.19)	.06 (.16)	.66* (.17)	.47* (.13)
Moment*Intraind., γ_{11}	.00 (.09)	-.02 (.06)	-.06 (.09)	-.07 (.08)
Irritation/Anger: Random Effects				
Variance intercept, σ^2_{u0}	.41	.31	.30	.16
Variance slope, σ^2_{u1}	.04	.01	.02	.03
Correlation, r^2_{u0u1}	.004	-.46	.19	.27
Residual variance, σ^2_e	1.47	.88	1.96	1.23
AIC	3477.98	2955.89	3749.99	3274.09

Note: Estimates are based on multilevel models of 1035-1036 observations from 55 participants.
* $p < .05$; † $p < .10$

Table 22

Relations Between Irritation/Anger and Regulation

	Regulation of Disengagement	Coping Strategies Total	Involuntary Engagement	Voluntary Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Irritation/Anger: Fixed Effects				
Intercept, γ_{00}	2.50* (.04)	.81* (.01)	.11* (.01)	.08* (.01)
Momentary Emotion, γ_{10}	-.01 (.03)	-.03* (.01)	.03* (.01)	.003 (.01)
Intraindividual Emo., γ_{01}	-.27* (.08)	-.06* (.03)	.05* (.02)	.01 (.02)
Moment*Intraind., γ_{11}	.07 (.06)	-.004 (.02)	.03+ (.01)	-.02 (.02)
Irritation/Anger: Random Effects				
Variance intercept, σ^2_{u0}	.02	.01	.002	.003
Variance slope, σ^2_{u1}	.01	.001	.001	.001
Correlation, r^2_{u0u1}	-.17	.42	.60	-.02
Residual variance, σ^2_e	.37	.06	.04	.03
AIC	1028.76	173.81	-172.55	-507.92

Note: Estimates are based on multilevel models of 981 observations from 55 participants for all except Regulation of Disengagement, for which estimates are based on multilevel models of 519 observations from 53 participants.
* $p < .05$; † $p < .10$

Table 23
Relations Between Concern/Worry, Action Readiness, and Actual Engagement and Disengagement

	Actual Disengagement	Desired Disengagement	Actual Engagement	Desired Engagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Concern/Worry: Fixed Effects				
Intercept, γ_{00}	.75* (.08)	1.79* (.10)	3.91* (.08)	3.12* (.10)
Momentary Emotion, γ_{10}	.00 (.04)	.04 (.05)	.07* (.04)	.01 (.05)
Intraindividual Emo., γ_{01}	.08 (.14)	.25 (.19)	-.03 (.16)	.04 (.20)
Moment*Intraind., γ_{11}	-.13+ (.07)	.23* (.09)	.07 (.06)	-.20* (.09)
Concerned/Worried: Random Effects				
Variance intercept, σ^2_{u0}	.22	.38	.31	.47
Variance slope, σ^2_{u1}	.02	.03	.02	.05
Correlation, σ^2_{u0u1}	-.16	.46	-.42	-.13
Residual variance, σ^2_{e}	1.28	2.31	.87	1.60
AIC	3313.53	3920.29	2945.78	3568.62

Note: Estimates are based on multilevel models of 1035-1036 observations from 55 participants.
* $p < .05$; † $p < .10$

Table 24
Relations Between Concern/Worry and Regulation

	Regulation of Disengagement	Coping Strategies Total	Involuntary Engagement	Voluntary Disengagement
	Estimate (SE)	Estimate (SE)	Estimate (SE)	Estimate (SE)
Concerned/Worried: Fixed Effects				
Intercept, γ_{00}	2.48* (.04)		.11* (.01)	
Momentary Emotion, γ_{10}	-.02 (.03)		.02* (.01)	
Intraindividual Emo., γ_{01}	-.004 (.08)	Did not	.03 (.02)	Did not
Moment*Intraind., γ_{11}	.15* (.06)	converge	-.001 (.01)	converge
Concerned/Worried: Random Effects				
Variance intercept, σ^2_{u0}	.04		.003	
Variance slope, σ^2_{u1}	.02		.00	
Correlation, σ^2_{u0u1}	-.48		.62	
Residual variance, σ^2_{e}	.37		.05	
AIC	1031.45		-134.34	

Note: Estimates are based on multilevel models of 981 observations from 55 participants for all except Regulation of Disengagement, for which estimates are based on multilevel models of 519 observations from 53 participants.
* $p < .05$; † $p < .10$

Appendix B: Figures

Figure 1

Hypothesized Neurophysiological Approach Readiness Trajectory Groups

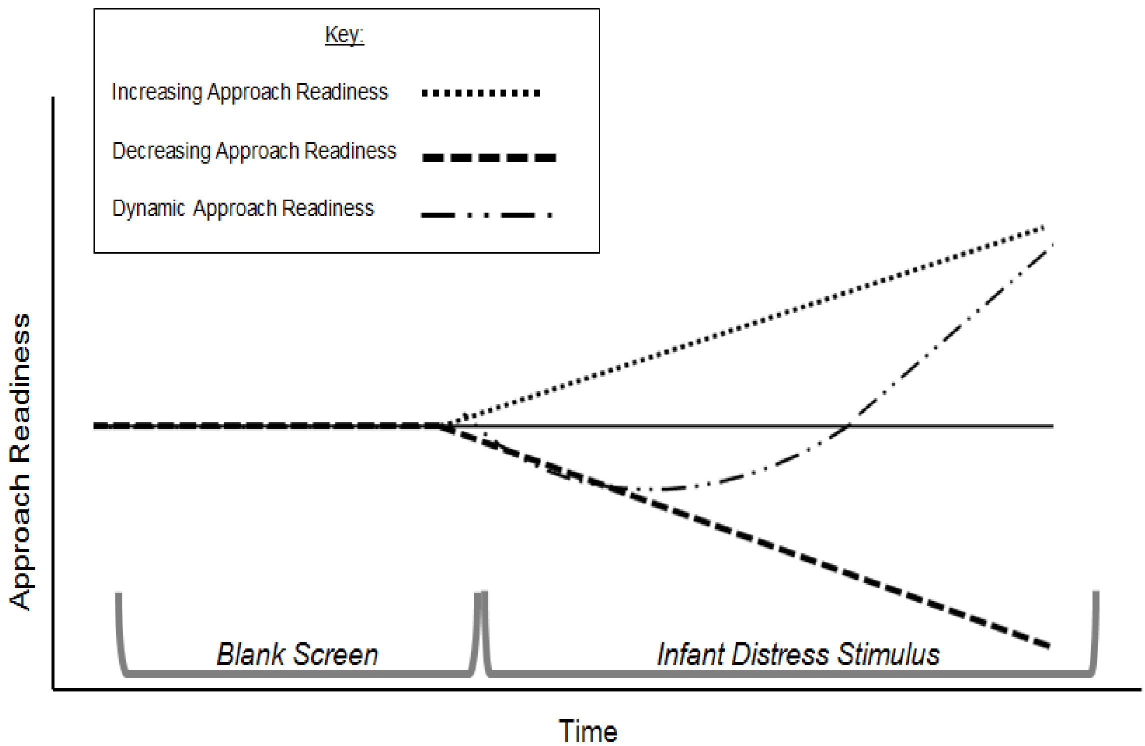
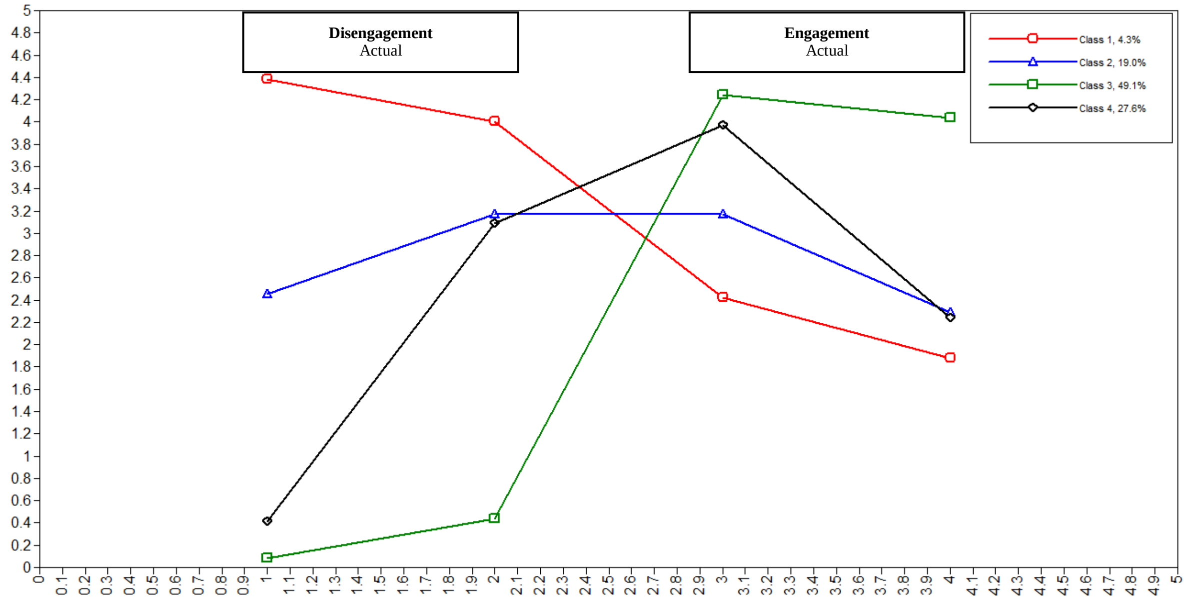


Figure 2

Four-class solution for Latent Class Analysis



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SELECTED PUBLICATIONS

Hajal, N.J., Neiderhiser, J.M., Moore, G.A., Leve, L.D., Shaw, D.S., Ge, X., Scaramella, L.V., Reid, J.B., Ganiban, J.M., & Reiss, D. (in press). Parents' angry responses to infant challenges: The role of positive family characteristics and gene-environment interplay. *Child Development.*

Marceau, K.P., **Hajal, N.J.,** Leve, L.D., Reiss, D., Shaw, D.S., Ganiban, J.M., Mayes, L.C., & Neiderhiser, J.M. (2013). Measurement and associations of pregnancy risk factors with genetic influences, postnatal environmental influences, and toddler behavior. *International Journal of Behavioural Development*, 37, 366-375.

Cole, P.M., Hall, S.E., & **Hajal, N.J.** (2013). Emotion dysregulation as a risk factor for psychopathology. In T. Beauchaine & S. Hinshaw (Eds.), *Child and Adolescent Psychopathology*. Hoboken, N.J.: Wiley & Sons.

SELECTED PRESENTATIONS

Hajal, N.J., Cole, P.M., Teti, D.M., & Moore, G.A. (2012). Parental self-efficacy and emotion in mothers of infants. Poster presented at the Biennial Meeting of the International Society for the Study of Behavioural Development, Edmonton, Alberta, Canada.

Hajal, N.J., Cole, P.M. & Robinson, L.R. (2011). Using ecological momentary assessment to understand relations between maternal emotion and coping during parenting challenges. Paper presented at the 2011 Biennial Meeting of the Society for Research in Child Development, Montréal, Québec, Canada.