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POSTPARTUM DEPRESSIVE SYMPTOMS: ASSOCIATIONS WITH BEHAVIORAL AND PHYSIOLOGICAL EMOTION REGULATION AND PHYSICAL ACTIVITY

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ABSTRACT

Postpartum depression is a widely researched condition that may have a negative impact on family interactions and infant development. The current study sought to examine factors related to lower levels of depressive symptoms reported by mothers during the postpartum period, including aspects of emotion regulation and physical activity. Forty-six mothers participated in a laboratory visit 5-8 months postpartum in which behavioral and physiological responses were observed during family interactions designed to elicit everyday emotions, with an emphasis on the change in responses as the emotion-eliciting demands of the context changed from negative to positive. Mothers reported on their depressive symptoms and leisure time exercise, and wore a pedometer prior to the visit. Findings indicated that increasing positive expressive behavior as contextual demands shifted was associated with lower levels of depressive symptoms. Moreover, mothers who reported higher levels of physical activity displayed higher levels of positive expressive behavior during a conflict discussion with their partners. These findings suggest that postpartum mothers may benefit from greater physical activity and the ability to use positive emotions to regulate stressful contexts. Future studies should examine postpartum mothers with a wider range of depressive symptoms and physical activity, as well as alternate measures of emotion and emotion regulation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1. INTRODUCTION

The postpartum period is a particularly important stage in family development. The addition of a new baby to the family may alter relationships and patterns of interaction among family members (e.g., Martell, 2001). Mothers, in particular, experience changes in the demands on their time, energy, and stress levels that may be exacerbated by dramatic physical changes that occur during the postpartum period. Relationships with partners may change as mothers adapt to the new family structure, and certain qualities of marital interaction that were functional before the new baby was born may no longer be functional after the birth (e.g., Houts, Barnett-Walker, Paley & Cox, 2008). One result of these changes may be postpartum depression or high levels of depressive symptoms.

Maternal depression is a widely researched condition known to have a negative impact on mothers' emotion regulation, family interactions, and infant social and emotional functioning (Goodman & Gotlib, 2002; Gross & Munoz, 1995; Mamun et al., 2009). Postpartum depression occurs in half a million women every year (Wisner, Parry, & Piontek, 2002), and episodes of depression that persist beyond 4 months postpartum have a greater risk of impairment for mothers (Campbell, Cohn, & Meyers, 1995).

One major difficulty for individuals with high levels of depressive symptoms may be difficulty regulating both positive and negative emotions (Forbes & Dahl, 2005; Gross & Munoz, 1995), although, to date more research has focused on excess of negative affect rather than absence of positive affect in relation to depression. Emotion regulation is defined as processes that monitor, evaluate, and modify emotional reactions (Thompson, 1994). In order for mothers to experience and express positive emotions with

their partners and new infants, they need to effectively regulate their own emotions during interactions, both by down-regulating (or decreasing) their negative emotions and up-regulating (increasing or maintaining) their positive emotions (Dix, 1991). Yet, as a result of changes in physiology, family composition, and the addition of new demands on mothers' time and energy, mothers' ability to down- regulate negative emotions and up-regulate positive emotions may require more effort than before.

These regulatory difficulties may influence the way in which mothers interact with their partners and infants, and mothers' ability to support infants' management of emotions and development of effective regulatory skills. Indeed, research has shown that mothers with depressive symptoms, particularly those whose symptoms are chronic, have been found to express fewer positive emotions during family interactions (e.g., Campbell et al.,1995; Raag et al., 1997; Ruscher & Gotlib, 1988), thus limiting their experiences of mutually positive interactions within families.

Despite much research examining the negative outcomes of postpartum depression and problematic family interactions, less work has examined factors that may promote positive emotion and mitigate depressive symptoms. One exception, exercise, has been found to have beneficial effects on mothers' health and well-being during the pre- and post-natal period, notably associated with lower levels of depressive symptoms (e.g. Downs, Dinallo, & Kiner, 2008). However, the mechanisms by which this process occurs remains unknown. Exercise enhances mood from less positive before exercise to more positive after, and relates to more effective physiological regulation (Al-Ani, Munir, White, Townend, & Coote, 1996; Steinberg et al., 1998). Perhaps exercise promotes the capacity to up-regulate positive emotions and down-regulate negative

emotions, thereby reducing depressive symptoms. To investigate this possibility, this project takes an innovative, multimodal approach to explore the associations of mothers' depressive symptoms during the postpartum period with emotion regulation and physical activity.

In the current project, mothers' behavioral and physiological responses were observed during a series of interactions with their partners (with their infants present) designed to first elicit negative, then positive emotions. By examining the change in behavioral and physiological responses as emotion-eliciting demands shift, the current project aimed to observe mothers' emotion regulation within a naturalistic family context for mothers with varying levels of depressive symptoms. Moreover, mothers' physical activity was examined in relation to depressive symptoms and emotion regulation.

Postpartum Depression

According to the *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV;* American Psychological Association, 2000*),* depression is considered to be a cluster of depressed mood or prolonged sadness, markedly diminished pleasure in most activities daily, poor appetite or overeating, sleep difficulties, low energy or fatigue, low self-esteem, poor concentration, and/or feelings of hopelessness. Research has shown that for each successive episode of depression, the risk of recurrence increases by 16% (Solomon et al., 2000). Moreover, 20% of people experience a relapse within 6 months of an episode, with 40% experiencing another one within 2 years (Hammen & Rudolph, 2003). Current theories of depression emphasize a biopsychosocial model in which physiological processes, psychological processes, and social factors interact over time in a dynamical and reciprocal manner (Akiskal & McKinney, 1975; Gilbert, 2006). Within

the framework of this model, it is posited that biological predispositions interact with family relationships to influence the development and maintenance of depressive symptoms (Gilbert, 2006).

Depression during the postpartum period is assessed and diagnosed the same way as any other type of clinical depression, but a qualifier is added that the episode occurs during the postpartum period. Depression can be measured from a dimensional or categorical perspective. From a dimensional perspective, depressive symptoms are assessed using rating scales such as the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996) and the Center for Epidemiological Studies Depression Scale (CESD; Radloff, 1977). A specific measure was developed to assess difficulties associated with risk for postpartum depression, the Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987). Higher scores on these self-report questionnaire measures are associated with risk for clinical depression. From a categorical perspective, cutoff scores of 16 or higher on the CES-D and the BDI-II signify risk for clinical depression, scores of 13 or higher indicate mild depression, and scores below 13 are considered minimal (Beck et al., 1996; Radloff, 1977). Mothers who score above 13 on the EPDS are considered at risk for depression (Cox et a., 1987). The current project combined indices of depressive symptoms to create a dimensional measure, and then created a categorical measure from the dimensional composite.

Women during the postpartum period experience rapid and dramatic changes in all three domains of the biopsychosocial model of depression, including physiology (changes in hormones), mood (increased stress), and social structure within the family. Consistent with the model, these rapid and dramatic changes during the postpartum

period coincide with high levels of depressive symptoms. Postpartum depression occurs in half a million women every year, and occurs in 13% (1 out of 8) of women after delivery (Wisner, Parry, & Piontek, 2002). Depression is considered to have postpartum onset if it begins four weeks within the timing of delivery, yet it is common to consider onset within three months of delivery (Kendell, Chalmers, & Platz, 1987). Major depressive episodes often resolve over time whether or not they are treated. Outpatients on a waiting list show a 10–15% reduction in symptoms within a few months, with approximately 20% no longer meeting the full criteria for a depressive disorder (Posternak & Miller, 2001). The median duration of an episode has been estimated to be 23 weeks, with the highest rate of recovery in the first three months (Posternak et al., 2006). Since episodes of depression that persist beyond 4 months postpartum have a greater risk of impairment for mothers (Campbell, et al., 1995), the current project observed mothers 5-8 months postpartum to sample mothers experiencing depressive symptoms beyond the normative duration. Mulitparous women (women who have given birth multiple times) are more likely to experience depressive symptoms during pregnancy and postpartum than primparous women, possibly as a result of additional stress from other children in the home or subsequent episodes (Gotlib, Whiffen, Mount, Milne, & Cordy, 1989; Righetti-Veltema, Conne-Perreard, Bousquet, & Manzano, 1998). Women who experience postpartum depression following pregnancy are up to 41% more likely to experience it again following a subsequent pregnancy (American Psychological Association**,** 2007). Compared to same-aged women of child-bearing age, post-pregnancy women experience significantly higher rates of major depressive disorder (Vesga-Lopez, Blanco, Keyes, Olfson, Grant, & Hasin, 2008). Moreover, rates of

subsyndromal depression or depressed mood are also high for women during the postpartum period (Goodman, 2007). Even though these women do not experience clinical depression, they may feel sadder and cry more often, feel more fatigued, and/or experience more guilt than they did before childbirth.

The increases in stress associated with changes in daily social functioning, as well as hormonal and other physiological changes associated with pregnancy and childbirth may contribute to the onset of maternal depressive symptoms during the postpartum period. Although many theories of postpartum depression implicate hormonal changes associated with childbirth, research examining causal associations between hormonal physiological changes and mothers' depressed mood is generally inconclusive and contradictory (see review by Hendrick, Altshuler, & Suri, 1998).

Regardless of the etiology, depressive symptoms may impair mothers' daily functioning in different domains. Depressive symptoms are associated with maladaptive cognitions, affect, and behavior, as well as problematic parenting practices (see review by Goodman, 2007). Maladaptive cognitions may result in increased negative views of mothers' ability to parent, less confidence in being a positive role model to children, and increased negative perceptions of the behavior of others (Goodman, 2007). Mothers with depression may be overwhelmed with the new stress in their lives, including caring for children and interacting differently with partners, which can have negative implications for family members as well.

Although this study did not examine effects on infants directly, findings may have implications for child mental health and development. Extensive research has documented the likelihood of negative outcomes for offspring of depressed parents. In a

study examining 220 families longitudinally over a 20-year period, children of parents with depression [measured by the Schedule for Affective Disorders and Schizophrenia (SADS)] had a 41% - 77% chance of developing a mental health disorder, which was 2-3 times the risk of children of non-depressed parents (Goodman & Gotlib, 2002; Weissman et al., 2006). Other negative outcomes for children with depressed parents compared to children with non-depressed parents include higher levels of cortisol and other signals of increased stress response, less optimal levels of excitability, withdrawal, and irritability, lower social competence, and more internalizing and externalizing behavior problems (Abrams, Field, Scafidi, & Prodromidis, 1995; Field, 2002; Field, Lang, Martinez, Yando, Pickens, & Bendell, 1996; Goodman, 2007; Gross, Conrad, Fogg, Willis, & Garvey, 1995; Lundy, Jones, Field, Nearing, Davalos, Pietro, et al., 1999). However, research suggests that chronicity and timing of depressive symptoms may be important factors in understanding the level of risk for mothers and children (Campbell et al., 1995; Keller et al., 1986).

In addition to negative implications for children, mothers' depressive symptoms also have negative implications for marital quality (e.g., Mamun et al., 2009). One associated feature of depression concerns interpersonal deficits in the ability to relate to others (Hammen, 2003). Thus, it is not surprising that marital distress and depression frequently occur together (Rehman, Gollan, & Mortimer, 2008). The direction of effects is unclear, although some older research suggests that marital depression precedes marital difficulties (Kumar & Robson, 1984; O'Hara, 1986). Mamun and colleagues (2009) longitudinally mapped the independent trajectories of reports of marital quality using the Spanier Dyadic Adjustment Scale (Spanier, 1976) and depressive symptoms using the

Delusions Symptoms Scales Inventory: State of Anxiety and Depression (Bedford & Foulds, 1978) over the course of 14 years in approximately 3,500 families. The authors discovered that the magnitudes of negative changes in depressive symptoms and perceived marital quality had a similar and bidirectional effect on each other over the 14-year period, suggesting that depressive symptoms and quality of the marital relationship may be related dynamically over time. Given the associations between depressive symptoms and marital relationships, the current project observed mothers' emotion regulation during marital interactions in relation to levels of depressive symptoms.

The evidence presented in this section suggests that mothers' depressive symptoms may have negative implications for mothers' well being, infant development and functioning, and marital interactions. These negative outcomes may occur, in part, through emotion exchanges during social interactions with family members. The following section introduces theories of emotion and emotion regulation during social interactions in order to subsequently understand links to depressive symptoms. A subsequent section discusses links between depressive symptoms and emotion responses and suggests that emotion regulation may be one factor associated with the maintenance and management of depressive symptoms.

Theories of Emotion

Emotions. As previously mentioned one difficulty for mothers with high levels of depressive symptoms may be managing negative emotions, particularly by increasing positive emotions. In order to understand mothers' emotion responses during interactions with family members for mothers with varying levels of depressive symptoms, it is first necessary to review the conceptual framework for emotions and emotion responses

broadly. Following this review, the more specific functions of emotions within a social context (such as family interactions) will be discussed. Emotions have been historically regarded as adaptive behavioral and physiological responses that arise from situations relevant for survival (James, 1894). Emotional responses tend to be relatively short and include changes in subjective experience, expressive behavior, and physiological responses that are triggered by evaluation of internal or external cues (Gross, 1999; Lang, 1995). Some theorists believe that behavioral expressions, physiological responses, and experiences are closely linked (Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, & Friesen, 1990), whereas other theorists believe that links between these responses are difficult to determine because "pure emotions" cannot be disentangled from behavioral or physiological responses to emotions (Campos, Frankel, & Camras, 2004). Despite differing theories, most agree that emotions have multiple components, including subjective experiential, behavioral, and physiological responses, and that these components are modestly associated with each other. Therefore, the current project assesses multiple measures of mothers' emotions, including behavioral and physiological responses.

Emotions within a social environment. As discussed earlier, one of the important components of the biopsychosocial model that contributes to the development and maintenance of depressive symptoms during the postpartum period concerns major social changes that occur within the family and mothers' daily lives. Therefore, it is important to study emotion exchanges within a social context, specifically. Emotions have been historically theorized to promote personal and group survival by allowing for important adaptations to the social environment (Darwin, 1873). The current project focuses on the

social-functionalist approach to emotions (Keltner & Kring, 1998). The social-functionalist approach to emotions suggests that within social interactions, emotions are dynamic, relational, multi-faceted responses that allow individuals to address social problems adaptively with social opportunities (Keltner & Kring, 1998). For example, when mothers and infants both experience positive emotion in an interaction, their attachment may strengthen. Moreover, if an infant cries because he/she is scared, mothers can respond by comforting infants, resulting in decreased fear in the infant and a more positive relationship between mothers and infants. Following the social-functionalist approach, emotions are thought to have both intrapersonal and interpersonal consequences (Campos, Campos, & Barrett, 1989). For example, experience of emotions is thought to have beneficial social consequences for individuals and relationships: emotions in one partner evoke responses in others that serve as incentives for actions and help to structure interactions (Keltner & Kring, 1998). A person experiencing joy may be both maintaining positive emotion, as well as signaling to continue the interaction with his/her partner. Thus, emotions have individual and social consequences during interactions.

Given such evidence linking individual emotions with social interactions, researchers have asserted that in order to truly understand emotional experience, the interconnected social environment that individuals function within must be acknowledged (Campos, Campos, & Barrett, 1989). The family is one specific social context in which different social subsystems are interconnected and embedded within larger systems (Minuchin, 1974). These different systems have reciprocal influences over each other, in that one or more individuals influence others in the system and others

influence them. Within an emotion framework, a family systems perspective suggests that individuals use direct and indirect strategies to manage emotions that may influence their own and their partners' emotions; partners' behaviors in turn may affect the individual's emotion responses (Thompson, 1994). For instance, in married couples, partners develop mutual, long-term influences on the others' emotional experiences and responses by reinforcing particular strategies through direction or modeling (Thompson, 1994).

Similar reciprocal emotion processes occur in parent-child relationships. Research has shown that mothers and their infants respond emotionally to each other in a systematic and contingent manner (Denham, 1993; Feldman, 2003). Parents' warmth and positive expressions have been suggested to model effective self-regulation, elicit positive emotion in children, and facilitate active emotion regulation (Eisenberg et al., 2005). Given the significant social changes that occur in family structure and function during the postpartum period, including mothers' increases in social interaction with infants and changes in interactions with partners, it is important to explore mothers' behavioral and physiological responses to emotion within the context of family interactions.

Emotion Expressive Behavior and Depression

One behavioral response through which emotions have traditionally been observed is facial expression (Cole, Martin, & Dennis, 2004). Facial expressions have been shown to reliably reflect individual emotional experience. Research has consistently found significant associations between self-report of emotional experience and emotion expression (Keltner & Ekman, 2000). Within the social-functional approach to emotions,

emotion expressions are thought to coordinate social interactions by providing information about others including partner's emotional state, intentions, nature of the relationship, and information about mental and physical health (Keltner & Kring, 1998). For example, if one partner rolls his/her eyes, it communicates his/her discontent and intention of expressing unhappiness, and reflects characteristics about the nature of the relationship. If the expression is anger, this could communicate the sender's dominance and hostility toward his/her partner (Knutson, 1996).

Additional modalities of expressive behavior have been examined, albeit less frequently than facial expressions. Verbal communication has been shown to reflect emotion in studies examining natural vocal expression during experienced emotions, induced emotional states, and simulated emotional states (Scherer, 2003). Body language and posture have also been examined, and research has shown that several bodily cues reliably differentiate happy, sad, angry, and neutral emotions and individuals are able to recognize these cues in others (Montepare, Koff, Zaitchik, & Albert, 2003). Thus, changes in different types of expressive behaviors indicate individual emotional experiences in response to others in the environment, and provide important information for others about individual emotion states.

With regard to depression, research has suggested that individuals with high levels of depressive symptoms have different responses to emotions in others than individuals with low levels of depressive symptoms. Individuals with depression display an impaired recognition accuracy and response bias to emotional facial expressions in others, specifically showing a lower than normal tendency to label happy faces as happy (Surguladze, Senior, Young, Brebion, Travis, & Philips, 2004). Moreover, in a study that

examined the ratings of 24 depressed and 23 non-depressed individuals to slides varying in pleasantness, individuals with depression responded more often with negative facial expressions to pictures designed to elicit negative affect, and more often rated pictures as less pleasant than non-depressed individuals (Sloan, Strauss, Quirk, Sajatovic, 1997). Within social interactions in the family, depressed mothers have been found to be more insensitive and inattentive, show lower levels of warmth, and express fewer positive emotions than their non-depressed counterparts (Cox, Puckering, Pound, & Mills, 1987; Field, 1995; Goodman & Brumley, 1990; Kendler, Myers, & Prescott, 2000). Although research has been performed using traditional laboratory interactions, additional research is needed to capture behavioral responses that reflect those in everyday life during the postpartum period. The current project asked mothers to have discussions with partners presumed to reflect everyday life in which to observe mothers' facial expressions, verbal communication, and bodily movement as expressive behaviors of emotion.

Physiological Emotion Indices and Depression

Another emotion response that is examined in the current project is mothers' autonomic physiological responses during interactions with family members. Emotion theorists have speculated that different emotions and emotion expressions are linked to patterns of autonomic nervous system activity and neurological activity in different areas of the brain (Keltner & Ekman, 2000). Autonomic responses are reliably consistent with different subjective emotion experiences (e.g., fear, anger, disgust) (Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, & Friesen, 1990), although there is not a one-to-one correspondence between specific types of emotion and specific physiological responses. One measure of autonomic functioning that corresponds to emotion responses is vagal

control, which reflects the functional modulation of heart rate through vagal nerve pathways (Porges, 2007). Vagal control originates in medullary structures where the nuclei of the cranial nerves lie (Porges, 2001). This area is thought to facilitate communication through myelinated vagal efferent pathways to target particular organs or select areas of organs, including the sinoatrial node of the heart (the pacemaker). The inhibition of the sinoatrial node allows for slowed heart rate and lower blood pressure, processes associated with a calm state.

Porges' Polyvagal Theory (2007) emphasizes the importance and adaptive function of physiological responses that support different types of social behaviors. For example, reduced vagal control supports fight or flight behaviors, whereas increased vagal control supports spontaneous social engagement behaviors. When vagal control is high, messages are sent through the vagal pathways to the sinoatrial node that allow slowing of the heart. However, when vagal control is low it allows heart rate to increase by removal of the inhibition of the sinoatrial node (Porges, 2001). For example, if an individual experiences anger during a conflict with a partner, vagal control would theoretically be withdrawn, allowing heart rate to increase and supporting a type of behavioral response to help individuals cope with the environment. Thus, vagal control provides a neural mechanism to affect physiological state by allowing for the deceleration or acceleration of heart rate and supports behaviors in response to social interactions (Porges, 2001).

The links between physiology and behavior are apparent within the" Social Engagement System" (Porges, 2007). The Social Engagement System includes the vagus nerve and other cranial nerves that regulate the social engagement muscles in the face and

head (Porges, 2007). This system collectively regulates nuclei that control eyelid opening, facial muscles, mastication muscles, laryngeal and pharyngeal muscles, and head turning muscles, all of which make up muscles controlling the behavioral expressions of emotions (Porges, 2007). Given the connections within this system, activation of muscles in the face and head could trigger physiological changes through the vagus nerve to increase or decrease vagal control that could in turn promote or impede social engagement behavior. For example, hearing an unfamiliar sound could initiate a decrease in vagal control, allowing for a fight or flight response through muscles in the face and head, whereas recognizing the smile of a stranger could promote increased vagal control to allow for a calm state to respond with a smile. Thus, the Social Engagement System includes behavioral and physiological responses to emotions, both of which contribute to adaptation during social interactions.

Research has linked facial expression in one partner during a social interaction to autonomic functioning in another partner. Specifically, for couples, distress in one partner was associated with heart rate acceleration in another, sympathy associated with deceleration, and the response of laughter to a partner reflected an increase in heart rate (Eisenberg, Fabes, Schaller, & Miller, 1989; Ruch, 1993). Studies that have examined physical and behavioral indices of emotion during marital conflict have found that men entering into a marital conflict discussion with lower heart rates displayed more facial anger during the interaction than men entering into marital conflict discussion with faster heart rates, even though both types of men were previously classified as violent (Gottman et al., 1995). This evidence suggests that physiological responses offer additional

information about emotion when combined with behavioral responses during marital interactions. This would likely be the case for other family interactions as well.

Vagal control is indexed by rhythmic variability in heart rate patterns that arise at the frequency of respiration, referred to as respiratory sinus arrhythmia (RSA) (Porges, Doussard-Roosevelt, Portales, & Suess 1994). RSA is a widely used index of vagal control that is associated with the influence of respiration on heart rate (Bernston, Quigley, & Lozano, 2007). The functional impact of vagal control is assessed by indexing the amplitude of RSA, which indicates variation in time between heart cycles at the rate of respiration (Porges, 2001). Moreover, Porges (2001) asserts that RSA provides an efficient and non-invasive method of assessing physiological attributes of the social engagement system, or for the purposes of the current project, physiological indices of emotion regulation during social interactions. It has been purported that lower RSA compared to baseline (i.e., RSA withdrawal) during a context designed to elicit negative emotion indicates regulation suggesting a need to cope with the current situation, and higher vagal control relative to baseline (i.e., RSA augmentation) during contexts designed to elicit positive emotions indicates regulation suggesting a content, calm state with regard to the current situation (Porges, 2007).

With regard to depression, research finds that individuals with high levels of depressive symptoms display differences in autonomic functioning, in addition to behavior, compared with non-depressed individuals. A meta-analysis of research on vagal control and depression suggested that depression was related to lower baseline vagal control in adults, which indicates lower capacity for regulation (Rottenberg, 2007). However, the effect was small to medium and explained only a small portion of the

variance. The authors acknowledged the limitations of several studies that could have influenced results (heterogeneity in depressive symptoms; variable intensity, timing, and course, etc.), so additional research examining the mechanisms for these associations with more specific patterns of depressive symptoms is warranted. Other research has shown that RSA increased with decreased symptoms in Major Depressive Disorder (Chambers & Allen, 2002; Khaykin et al., 1998). One study compared 25 depressed (based on the DSM IV criteria) individuals and 31 non-depressed controls during a film designed to elicit crying behavior, and found that following the resolution of tearful crying, RSA significantly increased among non-depressed individuals, but did not change for depressed individuals (Rottenberg, Wilhelm, Gross, & Gotlib, 2003). This research group additionally found that individuals with depression who exhibited higher levels of vagal control during a sad film were more likely to recover from depression 6 months later (Rottenberg, Salomon, Gross, & Gotlib, 2005).

Given links between vagal control and depression, researchers have attempted to treat depression using Vagal Nerve Stimulation (VNS). VNS consists of an implanted pulse generator that delivers electrical signals to stimulate the vagus nerve from a programming wand attached to a computer (Rush et al., 2000). Research has suggested that VNS is efficacious in remitting depression and is superior to treatment-as-usual (George et al., 2005; Rush et al., 2000). Thus, vagal control appears to be an important link to the maintenance and remission of depressive symptoms.

Another method that is related to the enhancement of vagal control (and the remittance of depressive symptoms) is exercise. A review study concluded that vagal control increases with physical activity training (Buch, Coote, & Townend, 2002). In a

longitudinal study examining the effects of intense training on relatively "unfit" individuals, the authors found that, following training, heart rate decreased significantly and heart rate variability and in most cases RSA increased significantly, suggesting increases in resting vagal control (Al-Ani, Munir, White, Townend, & Coote, 1996). Moreover, in a study examining male athletes, sustained exercise at moderate training levels was sufficient to increase heart rate variability indexes and vagal control similar to high intensity training (Tulppo et al., 2003). A later section will discuss the links between exercise and depression, possibly associated with increases in vagal control.

Despite much research on non-pregnant or postpartum adults and vagal control, there is a lack of research examining maternal vagal control during the postpartum period. Research suggests that baseline RSA declines over the second half of pregnancy, and that pregnancy generally reflects less parasympathetic modulation compared to pre and post-pregnancy periods (DiPietro, Costigan, & Gurewitsch, 2005). One study that did examine RSA during the postpartum period compared women who had not given birth during the follicular phase of the menstrual cycle (*N* = 14*)* to postpartum women who bottle-fed (*N* = 13*)* or breast-fed (*N* = 24*)* (Altemus et al., 2001). The authors found that postpartum women who bottle-fed had lower vagal control than lactating postpartum women and non-postpartum women during a task designed to elicit stress, and there were no differences in hormonal levels among the groups during this task (Altemus et al., 2001). Thus, breast-feeding appears to be associated with higher levels of vagal control. Despite these findings, no research to date has examined vagal control in postpartum mothers with depressive symptoms during a task designed to elicit specific emotions, particularly not positive emotions.

Mothers' vagal control has also been associated with infants' vagal control during the postpartum period, and mothers who have high levels of depressive symptoms and their infants show lower levels of vagal control than mothers with low levels of depressive symptoms and their infants (Field, 1995; Field, Diego, Hernandez-Reif, 2006). In addition, mothers' intrusive behavior during interactions with infants was exacerbated when mothers showed less change in vagal control, compared with mothers who showed more change in vagal control (Mills-Koonce et al., 2009). Thus, it appears that facial expression and autonomic nervous system functioning are linked to different emotional responses during social interactions within families.

There are several limitations to measuring emotions using behavioral and physiological responses. Emotion theorists have argued that "pure emotions" do not exist independent of responses or strategies that modify emotions, which makes it very difficult to signify a response to a particular emotion (Campos, Frankel, & Camras, 2004). There is no one-to-one link between a behavioral or physiological response and an emotional state (Davidson, Jackson, & Kalin, 2000), and associations are modest, perhaps as a result of display rules (individuals behave in a particular way depending on the audience) or individual differences. Many emotions are associated with the same behavioral or physiological responses, or one emotion can result in many different responses (Campos, Frankel, & Camras, 2004). For example, an increase in heart rate could follow the experience of anger or fear, but fear could also result in a withdrawal/freeze response or an approach response. Thus, it is necessary to exert caution when interpreting and making assertions about indices of emotional state. However, by using a combination of contextual information, knowledge of the correlates of emotions

through behavior and physiology, and an understanding of the beneficial functions of emotions during social interactions, indices of emotional state can be carefully inferred across different situations.

The current project used a unique design to enhance and expand the literature on postpartum depression to examine behavioral and physiological responses in mothers in relation to depressive symptoms during the postpartum period. It examined mothers' behavioral and physiological responses in social contexts designed to elicit negative and positive emotions. Thus, it was possible to explore similarities and differences in behavioral and physiological emotion regulation for mothers with varying levels of depressive symptoms during naturalistic interactions with family members.

Emotion Regulation and Depression

The current project examined behavioral and physiological changes in emotion-eliciting contexts as indices of mothers' emotion regulation during family interactions. Given the different theories and opinions regarding the functions and components of emotion, it is not surprising that emotion regulation has been difficult to define and measure (Cole et al., 2004). The most widely accepted definition of emotion regulation to date refers to processes that monitor, evaluate, and modify emotions (Thompson, 1994). This definition suggests that emotion regulation can involve maintenance and enhancement of an emotion as well as inhibition and reduction of emotions. Several theorists believe that emotion responses are very difficult to separate from emotions themselves (Campos, Mumme, Kermoian, & Campos, 1994; Stansbury & Gunnar, 1994). Yet, the definition of emotion regulation implies that emotion activation needs to be inferred independently before emotion regulation can be identified (Cole et al., 2004).

Additionally, researchers have asserted that emotions are inherently regulatory, yet simultaneously require regulation (e.g. Buss & Goldsmith, 1998; Cole, et al., 2004; Gross, 2005). For example, when an individual is sad, experiencing positive emotions may help to manage and decrease the sadness (e.g., watching a funny movie on a dreary day). However, positive emotion may also need to be regulated in certain situations in order to maintain optimal levels (e.g. maintaining laughter during a family game night) (Yap, Allen, & Ladouceur, 2008). It is also acknowledged that emotion regulation can be conscious or unconscious, and a continuum of processes that vary in the level of control, effort, and consciousness has been proposed (Gross, 2005; Wegner & Bargh, 1998). Although it is still unclear whether emotion and emotion regulation can be measured independently, given the conceptual distinction between the two, the current project infers emotion activation from behavioral and physiological responses during emotion-eliciting contexts and, consistent with the operationalization of emotion regulation in previous studies (e.g. Cole et al., 2004), measures emotion regulation as change in behavioral and physiological indices of emotion activation from one context to another as emotion-eliciting properties change.

In considering the importance of emotion regulation in relation to depression, two of the core features of depression are increased sadness and negative mood (increased negative emotions), and markedly diminished pleasure in most activities (decreased positive emotions). Although increased negative emotion is also reflected in other disorders such as anxiety, decreased positive emotion is a central feature in distinguishing depression from other types of psychopathology (e.g., Clark & Watson, 1991). Unlike the majority of past research on depression, the current project examines positive emotion

(and subsequent influences on emotion regulation) as a necessary component in understanding depressive symptoms in mothers. For individuals experiencing high levels of depressive symptoms, particularly anhedonia (lack of pleasure), the benefits of positive emotion may not be experienced as often as those experiencing low levels of depressive symptoms. Researchers suggest that depression may reflect poor affective flexibility and that individuals with high levels of depressive symptoms may become stuck in their negative mood, physiology, and behavior (Forbes & Dahl, 2005; Rottenberg, Wilhelm, Gross, & Gotlib, 2003). The Emotion Context Insensitivity (ECI) Hypothesis asserts that depressed mood and lack of positive emotion influences reactions to the environment by resulting in withdrawal and lack of motivation (Rottenberg, Gross, & Gotlib, 2005). As a result of lower motivation and susceptibility to environmental influences, individuals with depression may have difficulty enhancing positive emotion, recovering from negative emotion in response to different emotion eliciting contextual cues, or using effective regulatory strategies overall, leading to chronic negative emotion with little variation or positive emotion (Forbes & Dahl, 2005; Gross & Munoz, 1995).

One particular aspect of positive emotion, reward processing (the neural response to rewarding stimuli), has been found to be disrupted in individuals experiencing depression (Forbes, 2009). These disruptions in reward processing include the relative inability to respond to positive or negative emotional stimuli as well as deficits in the ability to use positive events to reframe situations and increase positive emotion (e.g., Rottenberg, Gross, & Gotlib, 2005; Tomarken & Keener, 1998). Research examining fMRI activity in the fronto-striatal network suggests that depressed individuals show an inability to sustain reward–related activity for prolonged periods, which implies reduced

positive emotion (Heller et al., 2009). Thus, the ability to decrease negative emotion and increase positive emotion appears to be difficult for individuals with high levels of depressive symptoms because emotions are not highly susceptible to external emotional stimuli or internal regulatory strategies. This is presumably the case for mothers with high levels of depressive symptoms during interactions with family members, such that they may not alter their emotional state in response to a partner's or infant's smile or laughter.

The difficulties that individuals with high levels of depressive symptoms experience are problematic within the social-functionalist perspective of emotions (Campos, Campos, & Barrett, 1989; Kelter & Kring, 1998). During social interactions, the ECI hypothesis implies that individuals with depressed mood would have limited reactivity to both negative and positive emotion in others, and would display less emotion to others. It is thought that insensitivity to changing environmental contexts may relate to psychosocial dysfunction and maladaptive patterns of interaction (Rottenberg, Gross, & Gotlib, 2005). However, different levels of depressive symptoms may have different influences on emotions during social interactions (Rottenberg, Ray, & Gross, 2007). It is possible that insensitivity to environmental cues may only occur when individuals have high levels of depressive symptoms and may not be present when an individual is experiencing lower levels of depressive symptoms.

Emotion-eliciting Properties of Different Contexts

Emotions, and in turn emotion regulatory processes, occur as a result of environmental and contextual cues (Gross & Thompson, 2007; Thompson, 1994). It is important to understand the specific social conditions under which emotions occur to

understand emotion reactions (Thompson, 1994). Emotional responses may be elicited differently based on moment-to-moment interactions with others. In a review on research examining marital interaction, Gottman & Notarius (2000) point out the importance of the type of task and context in detecting emotion within naturalistic marital interactions. Naturalistic marital interactions reflective of everyday life may elicit different levels of distress than those performed in laboratory contexts with less natural conditions (Gottman, 1979). Thus, the current project observed mothers' emotion responses during interactions with partners reflective of everyday life in one context designed to elicit negative emotion, a discussion about a conflict, and one context designed to elicit positive emotion, a discussion about recent positive experiences the family has had.

Much previous research has focused on emotion regulation in contexts designed to elicit negative emotions (e.g., Gross & Thompson, 2007). Individuals have reported trying to down-regulate or decrease negative emotions (particularly sadness, anger, and fear/worry) using cognitions and behaviors (e.g., cognitively reframing the event, doing a different activity) (Gross, Richards, & John, 2006). One method to down-regulate negative emotions may be with positive emotions. When the opportunity for positive emotion occurs, an individual may shift his/her current behavior to experience or maintain positive emotion (e.g., spending an additional five minutes playing a fun game with a partner) (Carver, 2007). The positive reappraisal of an event can lead to positive emotions, which can in turn broaden adaptive behavioral responses (Frederickson, 1998). Indeed, research has shown that self-report of positive reappraisal during day-to-day situations over a three week period resulted in increases in self-esteem, more positive adjustment, and increased overall positive emotions, whereas self-reported suppression of

the experience of positive emotion in day-to-day life resulted in increased negative emotion (Nezlek & Kuppens, 2008). The "Undoing Hypothesis" suggests that the experience of positive emotions following negative emotions broadens individuals' behavioral and cognitive repertoires for adaptive choices from the narrowing of repertoires that occurs with negative emotions, thus correcting or "undoing" the aftereffects of negative emotions (Frederickson, 2001; Frederickson, Mancuso, Branigan, & Tugade, 2000). Moreover, the Undoing Hypothesis suggests that positive emotions subdue increased cardiovascular reactivity caused by negative emotions (Frederickson et al., 2000). Consistent with this theory, smiling and increased levels of self-reported positive affect and well-being during contexts designed to elicit negative emotions were associated with faster recovery of cardiovascular functioning to baseline levels (Frederickson & Levenson, 1998; Tugade & Frederickson, 2004).

The evidence presented in this section suggests that positive emotion is associated with effective behavioral and physiological regulation of negative emotions. Moreover, the lack of positive emotion associated with high levels of depressive symptoms may result in more difficulty managing negative emotions during interactions both behaviorally and physiologically.

Exercise Behavior, Emotion, and Depressive Symptoms

Exercise behavior is associated with positive psychological well-being and may promote management of negative emotions using positive emotions. Exercise has been linked to improvements in mood, autonomic functioning, and reduced depressive symptoms in adults, and research is beginning to find these links in mothers during the postpartum period as well (e.g., Berger & Motl, 2000; Buch, Coote, & Townend, 2002;

Buckworth & Dishman, 2002; Long & van Stavel, 1995; Rethorst, Wipfli, & Landers, 2009; Poudevigne & O'Connor, 2006). Thus, exercise improves several aspects of functioning through biological, psychological, and social domains (consistent with the biospsychosocial model), particularly mood and physiology. Given the links between depression and exercise and between emotion regulation and depression, this section explores the possibility that emotion regulation may, in part mediate the association between exercise and depressive symptoms. As the majority of the research on exercise, emotion, and depressive symptoms covers the general population, the following review will first address this broad literature, and will conclude with a discussion of the literature specific to pregnancy and the postpartum period.

Exercise has been associated with many positive psychological outcomes. While the actual physiological mechanisms by which exercise may promote positive mood are not fully understood, physiologically, exercise does increase norepinephrine and endogenous opioid activity, which in turn, reduces actual stress responses (Salmon, 2001). Exercise may also help distract individuals from thinking about negative events and increase feelings of control, in turn reducing the negative influences of perceived stress (e.g., Buckworth & Dishman, 2002). Exercise has additionally been shown to reduce tension, fatigue, and negative emotions, while increasing levels of self-efficacy, enjoyment, and perceived control resulting in increased positive emotion (Berger & Motl, 2000). It has been found to have an anxioltyic effect, such that exercise reduces self-reported anxiety symptoms in community and clinical samples (Long & van Stavel, 1995; Wipfli, Rethorst, & Landers, 2008). It is suggested that acute bouts of exercise could serve as reduced physiological responses to stress, and these physiological changes

following exercise could result in behavioral adaptations (e.g., expressive behavioral responses to novel stressors) (Dishman, 1997; Dishman, Renner, White-Welkley, Burke, & Bunnell, 2000). Thus, exercise appears to increase positive mood and decrease negative mood through behavioral, psychological, and physical effects.

The Physical Activity Guidelines for Americans issued by the Federal Government state that adults should engage in at least 150 minutes per week of moderate (e.g., brisk walking) to vigorous (e.g., running, swimming) physical activity (United States Department of Health and Human Services [USDHHS], 2008). These evidence-based guidelines suggest that this level of physical activity per week is associated with substantial benefits, including improvements in psychological well-being and mood. However, changes in experienced emotion are most apparent when measured immediately before and after exercise (Salmon, 2001). One study found that aerobic exercise for 60 minutes resulted in an immediate increase in positive mood and a decrease in negative mood, with greater effects on positive mood than negative (Steinberg, et al., 1998). Moreover, exercise of 61-90 minutes had greater reductions in anxiety immediately following exercise than groups who exercised for shorter periods of time (Wipfli et al., 2008). However, if exercise is performed in a way that is more intense than individuals are accustomed to or expect, exercise may have no effect or negative effects on mood immediately following exercise (Salmon, 2001).

In addition to changes in the experience of emotion, exercise has been associated with behavioral and physiological responses to emotional experiences. One study found that elderly individuals who were more physically active had higher levels of positive expressions (Elavsky et al., 2005). Moreover, exercise has been linked to autonomic

functioning, specifically within the parasympathetic nervous system. Specifically, vagal control has been shown to increase with physical activity training (Buch, Coote, & Townend, 2002). Overall, evidence suggests that individuals who exercise regularly experience relatively higher levels of positive expression and vagal control compared to individuals who do not exercise regularly (Buch, Coote, & Townend, 2002; Elavsky et al., 2005; Lee, Wood, & Welsh, 2003), suggesting more effective emotion regulation. Given research on emotion regulation and depressive symptoms, these individuals would also presumably experience lower levels of depressive symptoms.

Indeed, exercise has been associated with the remittance of depressive symptoms. A recent meta-analysis suggests that both aerobic and resistance exercise improves depressive symptoms with an effect size of .80 (indicating a large effect) for clinical and non-clinical populations combined (Rethorst, Wipfli, & Landers, 2009). The authors additionally found that improvements within clinically depressed populations were significantly greater than the general population. A meta-analytic review of the effects of exercise training on individuals with major depression showed that an effect size of 1.42 (considered very large) existed for exercise training compared to control conditions, such as waitlist, placebo, or low-level exercise conditions (Statholpulou et al., 2006). Longitudinal studies have shown that exercise habits predict lower depressive symptoms as long as 25 years following reports of exercise (Camacho, Roberts, Lazarus, Kaplan, & Cohen, 1991**;** Paffenbarger, Lee, & Leung, 1994).

Moreover, older studies have established dose-response effects of the associations between exercise and depressive symptoms (North, McCullagh, & Tran, 1990; Tkachuck & Martin, 1999). In a meta-analysis that examined studies of associations between

exercise and depression in the general population, the authors found that the antidepressant effects of exercise may begin in the first session of aerobic exercise, and all lengths of programs (ranging from less than 4 weeks to greater than 24 weeks) showed significant decreases in depression, with the greatest decreases in programs 17 weeks or longer (North et al., 1990). In clinical populations, research has suggested that improvements in depressive symptoms can be seen as early as 5 weeks of low to moderate exercise activity three times a week for 20-60 minutes (Tkachuck & Martin, 1999). A recent meta-analysis sorted these effects by clinical and non-clinical populations and found that in clinical populations, effects for interventions of 10-16 weeks were greater than interventions of 4-9 weeks, whereas in the general population, interventions of 16 weeks or less resulted in significantly larger effects than those greater than 16 weeks, perhaps as a result of a floor effect (Rethorst et al., 2009).

Research has also examined exercise in comparison to already established treatments. A recent meta-analysis compared exercise vs. wait-list or placebo for individuals diagnosed with depression and found a large effect on the reduction of depressive symptoms (SMD -.82), and a moderate effect at long-term follow up, with no differences between exercise and cognitive therapy or antidepressant treatment for depressive symptoms (Mead et al., 2009). Blumenthal and colleagues (1999) focused on the comparison of exercise and antidepressant medication in treating depression. They found that treating adults age 50 and older with major depression using exercise training was as effective as treatment with antidepressants (sertraline hydrochloride [Zoloft], an SSRI), and the relapse rate at 10 months later was significantly lower in the exercise group than the medication or combined medication and exercise groups (Babyak et al.,

2000**;** Blumenthal et al., 1999). A recent randomized control trial by this research group focused on adults 40 years and older with major depression and found that patients who received supervised exercise, home-based exercise, and medication had higher remission rates than the placebo group, with no significant differences among remission rates in active treatment groups (Blumenthal et al., 2007). However, it is notable that placebo response rates were high in this study, suggesting that expectations, cognitions, and other factors may also be important in the reduction of depressive symptoms. This evidence suggests that exercise interventions are associated with reductions in depressive symptoms comparably to already established treatments, such as medication and cognitive therapy.

Although exercise is associated with the remittance of depressive symptoms, it remains unclear what factors actually drive these associations. As previously discussed, one important moderator that has been examined is dose, with longer exercise programs showing larger effects for clinical populations and an effect as early as 5 weeks (Rethorst et al., 2009; Tkachuck & Martin, 1999). A dose consistent with existing national exercise guidelines (at least 30 minutes of moderate-intensity exercise most days of the week) effectively treated mild to moderate major depression, but an exercise dose lower than the recommended guidelines was no different from a placebo (Dunn et al., 2005). The authors concluded that greater energy expenditure was associated with increased reduction of depressive symptoms.

Other studies have examined different types of moderators on the link between exercise and reducing depressive symptoms. Whereas the majority of randomized control trials examine aerobic exercise (jogging or walking), some studies focused on nonaerobic

exercise (strength training, coordination, and flexibility training) as a treatment for depressive symptoms. Some research has found that both aerobic and nonaerobic exercise reduced depressive symptoms and there were no differences in the effect (e.g., Doyne et al., 1987; Rethorst et al., 2009), yet other studies have suggested that moderate intensity aerobic exercise most effectively reduces negative emotion and enhances positive state compared to other types of exercise (Anshel, 2007). Given these contradictory findings, a recent review focused on randomized control trials using exercise to treat depressive symptoms and concluded that factors that moderate the effect of exercise on depressive symptoms are ambiguous and there is no clear relationship between the duration of exercise, type of physical fitness, supervision vs. home-based, group vs. individual, etc. (Mead et al., 2010). Thus, the current state of the literature is contradictory with regard to moderators of the effects of exercise on depression. Moreover, it is possible that other factors (or a "third variable") that have yet to be explored could better explain links between exercise and depressive symptoms. For example, perhaps the way depression is measured (categorically vs. dimensionally) influences findings, or geographic locations or seasons in which there is more sunlight allow for high levels of exercise and low levels of depressive symptoms. Research on this and other possible factors is warranted to clarify moderation and highlight more specific mechanisms.

Exercise Behavior and Depressive Symptoms during the Postpartum Period

Treatment of depressive symptoms during pregnancy and the postpartum period must include consideration of additional risks for the baby and the cost/benefit analysis for mothers. Recent guidelines from the American Medical Association recommend a thorough assessment and decision-making process for pregnant women with depression

that considers medication and dose selection, has ongoing communication, and includes monitoring of neonates in the immediate postpartum period (AMA, 2007). Many women do not want to risk taking medication during pregnancy and postpartum. Research has suggested that antidepressant medication to treat maternal depression during pregnancy may result in preterm delivery, restricted growth, higher levels of irritability, increased crying, and sleep and appetite problems (Hendrick et al., 2003; Kallen, 2004; Nordeng, Lindemann, Perminov, & Reikvam, 2001). When mothers take medication while breast-feeding, infants experience changes similar to changes in mothers' neurotransmitters (Epperson, Jatlow, Czarkowski, & Anderson, 2003). Moreover, one study found that the majority of women taking medication during pregnancy continued to experience difficulties with mood (Marcus, Flynn, Blow, & Barry 2005). The authors suggest that this may be a result of poor treatment adherence, and/or inadequate prescribing or monitoring of symptoms. Therefore, serious consideration of alternative treatments for depressive symptoms for these mothers is warranted. Exercise is a promising treatment for depression during the postpartum period that is beginning to be examined.

Consistent with research on other populations, a review of several studies on physical activity patterns in pregnancy concluded that compared to mothers who were active during pregnancy, mothers' inactivity during pregnancy was associated with concurrent worse mood, including increased fatigue, higher levels of depressive symptoms, and higher levels of anxiety symptoms (Poudevigne & O'Connor, 2006). Exercise has been shown to be positively associated with women's physical health and psychological well-being during pregnancy (Brown, 2002; Da Costa, Rippen, Dritsa, & Ring, 2003) and promote better outcomes for infants. Infants of mothers who exercised

during their third trimester of pregnancy weighed more at birth and were less likely to have a low birth weight than infants of mothers who did not exercise (Downs & Hausenblas, 2007; Leiferman & Evenson, 2003). Although evidence suggests that exercise has beneficial effects for mothers and infants, these studies are mostly correlational. Therefore, it is important to use longitudinal strategies and more sophisticated methodological techniques to determine causality of the associations between exercise and mood during pregnancy.

With regard to the reduction of depressive symptoms from exercise, a recent meta-analysis suggested that exercise does contribute to the management of postpartum depression (Daley, Jolly, & MacArthur, 2009). One study found that higher levels of exercise behavior during the first trimester of pregnancy explained part of the variance contributing to lower depressive symptoms in the second trimester, and the same pattern was found from the second trimester to the third trimester, and the third trimester to postpartum (Downs, Dinallo, & Kirner, 2008). However, depressive symptoms during pregnancy had more of an effect on postpartum depressive symptoms than exercise behavior did, possibly due to the decline in exercise that is common over the course of pregnancy. A randomized control trial examined the effects of a weekly exercise plus education group compared to an education only group on well-being and depressive symptoms for women postpartum, (Norman, Sherburn, Osborne, & Galea, 2010). Although exercise behavior (minutes per week of self-reported exercise) was not different between the two groups, the frequency of exercise did predict higher levels of self-reported well-being for these mothers, but did not predict lower levels of depressive symptoms. Although this study does not provide evidence to suggest that exercise

improves depressive symptoms postpartum, it does suggest that exercise increases well-being and positive affect. These findings collectively suggest that exercise is a promising intervention to increase positive affect in mothers postpartum, and perhaps an optimal dose of relatively higher levels of exercise, increased positive affect, decreased negative affect, and changes in vagal control could result in lower depressive symptoms as well.

Current Study

The current project examined postpartum mothers' depressive symptoms, physical activity, and behavioral and physiological responses during family interactions, with an emphasis on the change in expressive behaviors and physiological responses as the emotion-eliciting demands of the context changed. First, mothers and their partners were asked to engage in a Conflict discussion designed to elicit negative emotion. Next, they were asked to engage in a Positive Experiences discussion designed to elicit positive emotion. Emotion regulation was operationalized as change in expressive behavior and RSA between the Conflict discussion and the Positive Experiences discussion. This allowed for the examination of how mothers used positive emotion to regulate negative emotion (e.g. The Undoing Hypothesis).

An alternate way to assess the Undoing Hypothesis would be to see if mothers who express more positive emotion during a positive emotion-eliciting condition would subsequently show less negative emotion in a negative emotion-eliciting condition. However, this would require reversing or counter-balancing the order of the conditions. Counter-balancing would allow an assessment of change from a positive emotion-eliciting condition to a negative emotion-eliciting condition for half of the sample and an assessment of change from a negative emotion-eliciting condition to a positive emotion-

eliciting condition for the other half of the sample. This alternate approach is less likely to provide an adequate assessment of the Undoing Hypothesis because there are differential carry-over effects of positive and negative emotion. Whereas research suggests that a carryover effect exists for negative emotions (Carter, Mayes, & Pajer, 1990; Cohn & Tronick, 1983; Goldberg, Lerner, & Tetlock, 1999; Lerner, Small, & Loewenstein, 2004), moderate levels of positive emotion have not been shown to result in a carryover (e.g., Hornik, Risenhoover, & Gunnar, 1987). Therefore, a condition eliciting positive emotion before negative emotion may not be as effective for assessing mothers' use of positive emotion to regulate negative emotion. The current approach, to examine change from a negative emotion-eliciting condition to a positive-emotion eliciting condition, is a valid assessment of the Undoing Hypothesis because negative emotions have been shown to carry over into subsequent conditions.

The specific aims and hypotheses of the current study were:

Specific Aim 1: To examine whether mothers with higher levels of depressive symptoms during the postpartum period show patterns of behavioral and physiological regulation that differ from mothers with lower levels of depressive symptoms.

Hypothesis 1a: Emotion activation. In each interaction, mothers with higher levels of depressive symptoms were hypothesized to show greater negative expressive behavior, lower positive expressive behavior, and lower RSA compared to mothers with lower levels of depressive symptoms.

Hypothesis 1b: Emotion regulation. Consistent with the Emotion Context Insensitivity Hypothesis of depression (Rottenberg et al., 2005), it was hypothesized that higher levels of depressive symptoms would predict lesser rates of change in negative expressive behavior, positive expressive behavior, and RSA between the negative emotion-eliciting discussion and the positive emotion-eliciting discussion. These lesser rates of change suggest that these mothers would be less able to regulate negative emotions using positive emotions (e.g. The Undoing Hypothesis).

Specific Aim 2: To explore relations among depressive symptoms, emotion regulation, and physical activity in mothers during the postpartum period.

Hypothesis 2a: Mothers with higher levels of physical activity were hypothesized to display lower levels of depressive symptoms as well as greater decreases in negative expressive behavior, greater increases in positive expressive behavior, and greater increases in RSA as emotion-eliciting demands shift.

Hypothesis 2b: It was hypothesized that emotion regulation, change in expressive behavior and in RSA, would be a partial mediator in the association between depressive symptoms and physical activity, such that physical activity would relate to more effective emotion regulation, leading to lower levels of depressive symptoms. However, because these variables were measured concurrently, it is possible that the direction of these effects reflects a different pathway; therefore, other models will be explored.

Chapter 2. METHOD

Participants

Families (N = 46) with 5-8 month-old infants were recruited from a survey study of mothers during the postpartum period (G. Moore, PI, described below), the FIRSt (Families Interested in Research Studies) Families Database, flyers, and online research advertisements. Five to 8 months postpartum is an appropriate period for observing families after the birth of a baby. Prior research has found that episodes of depression that persist beyond 4 months postpartum may indicate greater likelihood of impairment in parenting behavior (Campbell, et al., 1995), and it is likely that mothers tend to return to exercising more regularly in the second half of the first year following the birth of a new baby.

The survey study targeted women in a broad geographical area in Central PA (Centre County, Blair County, Harrisburg, York). Through the Survey Research Center at Penn State University, mailings were sent to mothers with infants from age 0 to 8 months over a 6-month period based on birth announcements in newspapers. As part of the survey research, mothers were asked if they would be interested in participating in additional research studies. Those who responded affirmatively, who had an infant in the targeted range, and who indicated they would be willing to travel to the University Park campus were contacted for participation in the current study. Recruitment for the current study sought to oversample for mothers with at least mild levels of depressive symptoms indicated by a score of 13 or greater on the Center for Epidemiological Studies Depression Scale (CES-D, see below), however, as discussed below, it was not feasible to recruit the desired number of mothers who reported high levels of depressive

symptoms. For mothers recruited through the FIRSt Families database, telephone screening for depressive symptoms using the CES-D was performed prior to the laboratory visit. Mothers who had major pregnancy or birth complications, and/or infants with major medical problems were excluded. Both parents must have spoken English to participate. Families were compensated $50 for their participation in the study, including pre-visit questionnaires that they completed, wearing a pedometer for 7 days, and the laboratory visit. Based on survey responses, it was expected that ethnicity of study participants will be predominantly Caucasian with a range of income and education levels, reflecting the demographics of central Pennsylvania. Institutional Review Board approval (IRB # 32665) was granted by the Office of Research Protection at Penn State for all procedures discussed in the current study.

Study Design

Mothers with their partners (typically the infants' fathers) and 5-8 month-old infants were scheduled to visit the laboratory at the Child Study Center. Laboratory procedures were described to mothers and their partners approximately 2-3 weeks prior to the visit. A packet of information, including a copy of the consent form and a set of questionnaires (see below for description), was sent home prior to the visit. A pedometer for mothers to wear for 7 days prior to the laboratory visit was included in the pre-visit packet, along with instructions for use. Mothers were instructed to record daily readings from the pedometer, and were asked to bring the pedometer and packet of questionnaires with them to the laboratory visit.

Procedures were reviewed upon arrival as part of the informed consent process. Following consent, mothers and partners decided upon one or more problem topics to

discuss. Both parents and the infant were fitted with three electrodes with wires connected to separate ambulatory units to collect physiological information about heart rate. (Two additional electrodes were fitted to record skin conductance, which were not analyzed in this study). Although physiological data was being collected from all family members, only mothers were the focus of the current study. Parents were each given a fanny pack in which to place the ambulatory unit. Parents were seated on a couch, and the infant was placed in a high chair facing parents. Parents were instructed to attend to the infant in any way that they normally would at home but to try to leave the infant in the seat. Baseline heart rate was collected for five minutes while parents quietly filled out questionnaires.

Following baseline data collection, mothers and their partners were prompted to begin a discussion of the problems that they previously identified. This lasted 10 minutes. This task asked parents to discuss the problem topic that they identified, and has been shown to elicit a variety of reactions from parents, including negative emotions (Schudlich & Cummings, 2003; Schudlich, Papp, & Cummings, 2004). This task may not elicit negative emotion in all participants, but it is a laboratory method that has been shown to be similar to conflict discussions with partners in mothers' everyday lives (Schudlich, Papp, & Cummings, 2004). A naturalistic context such as this allows mothers to experience a conflict discussion typical of everyday life within a laboratory setting and presumably reflects emotion regulation representative of that during interactions at home. Given research suggesting that the last 5 minutes of marital conflict discussions have been found to elicit the greatest change in RSA (Moore, DuRocher Schudlich, Propper, Heilbron, & Cox, 2010), this discussion was split into two 5-minute segments for

analyses (Conflict1 and Conflict2). Following this problem discussion, the research assistant prompted the parents to immediately begin discussing recent positive experiences their family had (Pos Ex). This discussion lasted 5 minutes. As part of the larger study, parents were then asked to engage in the Still-Face Paradigm (SFP; Tronick, Als, Adamson, Wise, & Brazelton, 1978). Data from this part of the study were not used in the current research. Following this procedure, electrodes were removed and the visit was concluded.

Measures

Demographic information To collect information about infant age, mothers' age, birth parity, weight, medication, infant feeding method, education level, ethnicity, and income level, mothers were asked to complete a demographic questionnaire prior to the laboratory visit (survey respondents already completed this form) and a questionnaire during the visit. Factors affecting metabolic processes have been shown to affect baseline RSA (Bernston, Quigley, & Lozano, 2007). Moreover, breast-feeding has been linked to increased levels of vagal control compared to bottle-feeding (Altemus et al., 2001). Thus, this information was collected.

Depressive symptoms To screen for depressive symptoms mothers completed the Center for Epidemiological Studies Depression Scale (CESD; Radloff, 1977). The CES-D has 20 items rated on a 4-point scale based on the frequency with which the item has been experienced in the previous week. Items are summed to create an overall symptom score. A score of 16 or higher signifies the possibility of clinical depression and 13 or higher indicates mild depression (Radloff, 1977). The CES-D has been shown to be reliable and valid for different demographic groups (Radloff, 1977), has inter-item

reliability estimates of α =.85 to .91, test-retest reliability coefficients of *r* =.40s to .70s, and is correlated with the Beck Depression Inventory (BDI; Beck, 1972), *r* > .80 (Roberts, 1980; Mahard, 1988).

In the pre-visit packet, to obtain a measure of depressive symptoms during the postpartum period, mothers were given the Edinburgh Postnatal Depression Scale (EPDS; Cox, et al., 1987). This 10-item scale assesses mothers at risk for postpartum depression. It demonstrates sensitivity from 68% to 86% and specificity from 78% to 96%, shows predictive validity during the postpartum period, and has internal consistencies of α = .80 (Cox et al., 1987; Dennis, 2004; Murray & Carothers, 1990).

To assess current symptoms of depression on the day of the laboratory visit, mothers were asked to fill out the BDI-II during the laboratory visit. The BDI-II (Beck, Steer, & Brown, 1996) is a 21-item scale designed to assess the severity of depressive symptoms. It demonstrates convergent validity with other measures of mental health (*r* =-.65) and excellent internal consistency (α = .94). One of the questions on both the BDI and EPDS asks mothers about suicidal ideation. If that question had been endorsed, the Principal Investigator's advisor is a licensed clinical psychologist and would have been immediately notified. A detailed set of questions were developed to assess safety and primary research assistants (who are all graduate students in the clinical psychology program) have been trained in these procedures. If the P.I.'s advisor was unavailable, CAN HELP, Centre County's 24 hour crisisline, would have been notified. This safety plan was approved by the Penn State Institutional Review Board. None of the participants endorsed this question during the study.

Since the CES-D was used as a screening measure for risk for depression and was asked of mothers several weeks prior to the other measures, depressive symptoms from the EPDS and BDI were standardized then averaged to create a continuous measure of depressive symptoms. It was possible that associations would only be evident for mothers at risk for clinical depression. To identify mothers whose levels of depressive symptoms suggested risk for a clinical diagnosis of depression, following prior research (e.g., Gotlib, Lewinsohn, & Seeley, 1995) a categorical variable was created to group mothers into high and low risk categories based on scores 1 standard deviation at or above the mean of the composite score of depression ($M = 0.00$). This method was used rather than a cutoff score because a standardized composite of two different measures was used to create a dimensional index of depressive symptoms. This resulted in two groups: mothers scoring at or above 1 standard deviation from the mean ($N = 5$) and the rest of the sample below this cutoff ($N = 41$). Based on the CES-D, the mean level of depressive symptoms for mothers scoring in the high group was 19.20. The mean value of mothers in the low group was 6.83.

Physical activity To assess mothers' leisure exercise behavior, mothers completed The Godin Leisure Time Exercise Questionnaire during the laboratory visit *(LTEQ;* Godin & Shepard, 1985). The questionnaire asks about typical leisure-time exercise habits, including frequency and intensity of exercise. It was used to examine the frequency of strenuous (e.g. running, aerobic dance), moderate (e.g. brisk walking), and mild (e.g. strolling) physical activity performed for at least 15 minutes during leisure time during the past week. Total leisure time exercise is determined by multiplying each participant's strenuous (multiplied by 9), moderate (multiplied by 5), and mild

(multiplied by 3) scores, and adding the total together (Godin & Shepard, 1985). The validity and reliability of the LTEQ has been established (Downs & Hausenblaus, 2004; Downs, Dinallo, & Kirner, 2008; Godin & Shepard, 1985; Hausenblaus & Downs, 2005; Hausenblaus, Downs, Giacobbi, Tuccitto, & Cook, 2008; Jacobs, Ainsworth, Hartman, & Leon, 1993), including a test-retest reliability of (*r = .74)* and significant correlations with other types of physical activity measures.

To obtain an objective measure of physical activity, following previous research (e.g. Downs, Dinallo, & Le Masurier, 2009), mothers were asked to wear a pedometer for seven consecutive days prior to the laboratory visit. The *New Lifestyles Digi-Walker SW-200* (New Lifestyles, Inc., 2011) is a small, lightweight pedometer that clips onto the belt or waistband. It is a non-invasive, objective measure of physical activity that measures the number of steps taken. Mothers were asked to record daily readings from the time they woke up until they went to sleep. Readings were averaged across the seven days to obtain an average number of steps per day.

Behavioral Expressiveness and Regulation

Emotion expressiveness behaviors Mothers' expressive behaviors were observed second-by-second over the course of Conflict1, Conflict2, and Pos Ex. Following prior research using observations of mothers with depression (e.g. Cohn, Campbell, Matias, & Hopkins, 1990; Moore, Cohn, & Campbell, 1996; Moore, 2009), coders determined at each second if mothers were displaying positive, negative, or neutral expressions. To identify additional types of positive and negative affective behaviors, an adaptation of the Specific Affect (SPAFF; Coan & Gottman, 2007) coding system was used. This system identified vocal and behavioral (e.g., gestural) affective behaviors in addition to facial

expressions and was also applied on a second-by-second basis. These included behaviors thought to reflect anger, belligerence, contempt, criticism, disgust, fear/tension, sadness, and whining (negative emotions) and affection, enthusiasm, humor, and validation (positive emotions). Undergraduate coders were trained to a minimum inter-rater reliability at a kappa of .70 with a criterion coder. Inter-rater reliability was an average kappa of .81 (.71 - .95) for the full Conflict discussion and .77 (.70- .85) for Pos Ex.

Based on these codes, two new variables were created at each second that indicated whether some type of negative and some type of positive expressive behavior occurred (either facial or SPAFF). Two composite percentage scores were then computed that indicated the percentage of time that each mother showed any type of negative expressive behavior (NEB) and positive expressive behavior (PEB) during each 5-minute segment (Conflict1, Conflict2, and Pos Ex) .

Behavioral regulation Indices of regulation were computed using a set of change scores. Behavioral emotion regulation was computed by subtracting NEB and PEB in Conflict2 from NEB and PEB in Pos Ex (ΔNEB and ΔPEB).

Physiological Measures

Vagal control Heart rate from mothers was monitored continuously during the course of the laboratory visit using the Mindware software system, version 3.0 (Mindware Technologies, LTD, 2010). Mothers wore three electrodes attached to a wireless ambulatory unit that sent ECG signals to a computer. Vagal control was indexed by RSA (Porges, et al., 1994). Data were compiled and edited in 60-second epochs (as recommended by the Mindware Technologies) for each 5-minute segment of baseline, Conflict1, Conflict2, and Pos Ex, using the Heart Rate Variability Software (Mindware

Technologies, LTD, 2010). An index of RSA was computed by this software program for each 60-second epoch, and RSA epochs were averaged across each 5-minute segment.

Physiological regulation To index physiological regulation of emotion, following prior research (e.g., Buss, Goldsmith, Davidson, 2005; Calkins, 1997; Oosterman & Schuengel, 2007; Suess & Bornstein, 2000), change scores were computed using RSA. RSA in Conflict2 was subtracted from RSA in Pos Ex (ΔRSA). Some research has used change from baseline as an index of regulation but because RSA is a dynamic measure that changes quickly in response to social cues, change from the preceding conflict discussion was thought to provide a better assessment of physiological regulation.

Chapter 3. RESULTS

Missing Data Treatment

With regard to the demographic variables, age information was missing for three mothers. To retain data for primary analyses, the mean age for all mothers (31.02 years) was substituted for those mothers missing data. Weight information was missing for two mothers, so the mean weight (169.77 lbs) was substituted.

Data were additionally missing for depressive symptoms measured using the BDI and the EPDS, due to changes in procedures and participant error. Three mothers failed to complete the BDI because they did not see the second page. Seven mothers did not complete the EPDS because they participated prior to the decision to use this measure in the study. Mothers with missing depressive symptom data did not differ from mothers with complete data on any demographic variable. Single imputation method was used, which develops estimates for the missing values that are consistent with the multivariate trends based on variables that were theoretically and empirically shown to be associated with the current measures, and adds stochastic or random variability (Widaman, 2006). To impute data for the BDI, information from the CES-D was used, and to impute data for the EPDS, data from both the CESD and the BDI were used.

Eleven mothers were missing pedometer data. Eight of these mothers participated in the visit prior to the decision to use the pedometer in the study and three were unable to use the pedometer prior to or following the study. None of these mothers differed from other mothers on any demographic variables. To impute missing data on pedometer activity, single imputation method was again used based on data from the LTEQ. Means

and standard deviations of the final variables are shown in Table 1. All behavioral and physiological data were complete.

Preliminary Analyses

Mothers were, on average 31.02 (SD= 5.11) years old, ranging from 20 to 42 years; infants were, on average, 34.20 (SD = 4.68) weeks postpartum, with a range of 23 to 50 weeks, thus we were seeing mothers approximately eight months postpartum.. In terms of education, 9% of mothers had a GED or high school diploma, 13% had some college or an associate's degree, 37% had a bachelor's degree, and 37% had a postgraduate degree. For total family income, 9% had less than $30,000 per year, and 36% had more than $90,000 per year, with a median in the $50,000- $89,000 range. Thirty-five percent of mothers were first time mothers, 37% had one other child, 22% had 2 other children, and 6% had 3 other children.

A goal of the study was to screen for 25% of mothers with mild depressive symptoms based on the CESD. However, perhaps as a result of the difficulty families of depressed mothers may have in making an effort to travel to the laboratory, only 5 out of the 46 mothers met this criterion. Using the CES-D for the current study of mothers willing to participate, mothers, on average, had a score of 8.16 (SD = 7.56) with a range of 0 through 46. Therefore, depressive symptoms were relatively low for this sample.

Physiological and behavioral measures were examined in relation to demographic variables. Maternal age was significantly correlated with baseline RSA and RSA during Conflict2, such that younger mothers had higher levels of RSA (r = -.59, p < .01 and r = -.*37*, p < .05, respectively). Birth parity, infant age, household income, and education were not associated with any physiological or behavioral indices.

Additional Pearson correlations were computed to examine influences known to be related to RSA. Maternal weight was negatively associated with RSA across all segments (r = -.44 to -.51, $p < .01$) such that higher weight was associated with lower RSA, consistent with previous research suggesting that metabolic processes can influence RSA (Bernston et al., 2007). Method of infant feeding and whether mothers were on medication were not associated with RSA. Based on these preliminary analyses, all analyses incorporating RSA indices used maternal age and weight as covariates.

Depressive symptoms, LTEQ, and pedometer activity were examined in relation to demographic variables. Depressive symptoms were not related to any demographic variables. LTEQ was associated with maternal age, such that older mothers reported higher levels of leisure time physical activity (r = .31, $p < .05$). No other demographic variables were related to pedometer readings or the LTEQ. Therefore, maternal age will serve as a covariate when examining measures of physical activity. Pedometer and LTEQ reports were significantly correlated (r = .39, $p < .05$).

Pearson correlations were computed to examine associations among emotion regulation variables (change from Conflict2 to Pos Ex). None of the variables were associated with any others (See Table 2). Moreover, none of the variables were associated with maternal age, weight, or birth parity.

Method Check

Pearson correlations were performed for overall PEB, NEB, and RSA across the three segments of the discussions and baseline RSA (see Table 3). RSA also correlated across the segments, but was not correlated with expressive behaviors. PEB was

correlated across segments, and was negatively correlated with concurrent NEB in Pos Ex . NEB was correlated only within the Conflict discussion.

To assess whether the different conditions elicited the expected affective responses at a significant level, repeated measures analysis of variance were conducted separately for mean levels of PEB, NEB, and RSA in Conflict1, Conflict2, and Pos Ex (see Table 4). For PEB, there was a significant quadratic trend for within-subjects effects *(F* = 54.78, $p < .001$). Post-hoc analyses that examined mean differences between each segment based on the Least Significant Difference indicated that there were significant differences between Conflict1 and Conflict2, Conflict1 and Pos Ex, and Conflict2 and Pos Ex (*p's* < .001). The profile across segments was as expected- PEB was highest in the positive experiences discussion (See Figure 1).

For NEB, there was also a significant quadratic effect ($F = 38.60$, $p < .001$) (See Figure 1). Post-hoc analyses based on the Least Significant Differences indicated that the patterns were as expected, with higher levels of NEB in both parts of the Conflict compared with Pos Ex. Both 5 minute segments of the Conflict were significantly different from Pos Ex ($p < .001$), and there was a trend for differences between the two parts of the Conflict for NEB *(*$p < .10$), such that the Conflict2 had higher levels of NEB than Conflict1.

To determine the influence of the discussions on mothers' RSA (Table 4), the same procedure was followed using RSA during Conflict1, Conflict2, and Pos Ex, with maternal age, weight, and baseline RSA as covariates. When taking into account maternal age, weight, and RSA baseline, there were no significant differences in RSA between any of the episodes.

Tests of Study Hypotheses

Hypothesis 1a. In each segment, mothers with higher levels of depressive symptoms were hypothesized to show greater negative expressive behavior, lower positive expressive behavior, and lower RSA compared to mothers with lower levels of depressive symptoms.

First, Pearson correlations were computed to examine associations between depressive symptoms and emotion indices in Conflict1, Conflict2, and Pos Ex. None of the associations between the continuous measure of depressive symptoms and the emotion indices were significant. Using the categorical measure (depression group), there were no significant differences between mothers with relatively high levels of depressive symptoms and those with relatively low symptoms on any behavioral or physiological emotion indices.

Hypothesis 1b. Higher levels of depressive symptoms were hypothesized to predict lesser rates of change in NEB, PEB, and RSA between the negative emotion-eliciting segment and the positive emotion-eliciting segment.

To examine patterns of emotion regulation for mothers with different levels of depressive symptoms, hierarchical regressions were conducted separately for each emotion regulation variable, computed as change scores (ΔNEB, ΔPEB, and ΔRSA from Conflict2 to Positive Experiences) as the dependent variables and depressive symptoms as the independent variable. To account for mothers' initial rates of emotion reactivity, the level of NEB or PEB or RSA, respectively was added to the model as a covariate. This took into account that the degree of change in, for example, NEB, may be affected by how much negative affect the mother was expressing to begin with.

ΔNEB was regressed onto NEB in Conflict2 and depressive symptoms. Neither depressive symptoms nor depression group were significant predictors of ΔNEB, with power at 1.00.

ΔPEB was regressed onto PEB in Conflict2 and continuous depressive symptoms. Depressive symptoms were not a significant predictor, with power at .79. Depression group then was examined in predicting ΔPEB, and was not a significant predictor, with power = .82.

ΔRSA was regressed onto maternal age, weight, RSA in Conflict2, and continuous depressive symptoms. Depressive symptoms were not a significant predictor. Power was calculated to be .30, indicating insufficient power to detect a significant effect (Length, 2006). Depression group was not a significant predictor, with power at .32, indicating insufficient power to detect a significant effect. Analyses were rerun without covariates, and power remained insufficient.

Hypothesis 2a. Mothers with higher levels of physical activity were hypothesized to display lower levels of depressive symptoms as well as greater decreases in NEB, greater increases in PEB, and greater increases in RSA as emotion-eliciting demands shift.

Overall, leisure time physical activity ratings were relatively low. Table 1 shows the overall LTEQ score, as well as the numbers of 15-minute bouts per week for mild, moderate, and strenuous exercise. On average, mothers reported 86 minutes per week of mild exercise, 58.5 minutes per week of moderate exercise, and 20.4 minutes per week of strenuous exercise. They walked an average of 7,728 steps per day during the week they wore the pedometer. Overall, these mothers are displaying lower levels of physical

activity than are recommended by the guidelines, (150 minutes per week of moderate to strenuous physical activity). Only five mothers in the sample were at or above the recommended exercise dosage.

Pearson correlations were performed between continuous physical activity measures and depressive symptoms, and physical activity measures and emotion indices. With respect to physical activity and depressive symptoms/depression group, correlations were not significant, but the direction of effect was in the expected negative direction (See Table 5).

None of the physical activity measures were associated with NEB (See Table 5). The LTEQ was positively associated with PEB in Conflict1 and Conflict2 (r = .33, p < .05, and r = .33, p < .05). With regard to RSA and physical activity indices, the overall level of RSA during Conflict1 was associated with pedometer activity (r = -.29, p < .05), such that higher levels of physical activity were associated with lower levels of RSA during Conflict1, but not with any other measures of RSA, including ΔRSA. With respect to the emotion regulation change scores, none of the variables were significantly related to either measure of physical activity (See Table 5).

The National Guidelines for Physical Activity suggest that postpartum mothers should spend at least 150 minutes a week engaging in moderate physical activity for beneficial results. Therefore, a categorical variable was created based on whether mothers met Physical Activity Guidelines based on their self-report on the LTEQ. Independent samples *t*-tests were performed on all variables of interest. Consistent with the continuous findings based on the LTEQ, mothers who met Guidelines showed more PEB in

Conflict1 and Conflict2 than mothers who did not meet the Guidelines (t = 4.08 and 6.50, $p < .05$). No other variables were related to Guideline status.

Hypothesis 2b: Emotion regulation was hypothesized to be a partial mediator in the association between depressive symptoms and physical activity, such that physical activity would relate to more effective emotion regulation, leading to lower levels of depressive symptoms.

As a result of the lack of association between physical activity and depressive symptoms, as well as physical activity and emotion regulation, path analyses were not conducted and alternate models were not tested.

Post hoc Analyses

Additional analyses were performed to explore possible reasons for the unexpected lack of findings. The hypothesis regarding relations between depressive symptoms and change in behavioral expression was based on a conceptualization that a decrease in negative emotion and/or an increase in positive emotion between a context designed to elicit negative emotion and one designed to elicit positive emotion would indicate the ability to use positive emotion to manage and ultimately decrease negative emotion. These predictions were not supported by the analyses in which change in negative and change in positive expressive behavior from a negative-eliciting condition to a positive-eliciting condition were examined separately in relation to depression, controlling for initial levels of negative and of positive emotion, respectively. Consistent with the primary conceptualization of this study that positive emotion could be used to regulate negative emotion (i.e., The Undoing Hypothesis; Frederickson, 2003), the model of change in negative expressive behavior (ΔNEB) was refined by including the effect of

positive expressive behavior (PEB in the PosEx) in predicting change in negative expressive behavior (ΔNEB). In addition, as an indicator of physiological responsivity, RSA in Pos Ex was added to the model to examine whether physiological response contributed to ΔNEB. The same procedure was performed in examining the influence of NEB on ΔPEB.

Therefore, to examine the effects of PEB and RSA emotion indices in the Pos Ex condition on ΔNEB, ΔNEB was regressed onto NEB in Conflict2, PEB and RSA in Pos Ex, and continuous depressive symptoms or depression group. With power at 1.00, neither depressive symptoms nor depression group were significant predictors. However, in both models, PEB in Pos Ex was a significant predictor of ΔNEB (β = -.18 and -.20, p <.01) and NEB in Conflict2 was a significant predictor (β = -.93, p < .001). Higher levels of PEB in Pos Ex and NEB in Conflict2 predicted greater change (decreases) in NEB. RSA was not a significant predictor.

In predicting ΔPEB from level of PEB in the Conflict2 episode and level of NEB and RSA in Pos Ex, with power = .97, depressive symptoms were not a significant predictor of ΔPEB. Depression group significantly predicted ΔPEB (β = -.13, p < .05), such that being in the low depression group independently predicted a greater increase in positive expressive behavior from Conflict2 to Pos Ex. In both models, NEB in Pos Ex predicted ΔPEB (β = -.37 and -.34, p < .05), and PEB in Conflict 2 predicted ΔPEB (β = -.46 and -.47, p < .01). Lower levels of NEB in Pos Ex and PEB in Conflict2 predicted greater increases in PEB. RSA did not significantly predict ΔPEB.

Based on the current findings, a graphic model to best describe the data is depicted in Figure 2. The data suggest that there is an indirect path between depressive

symptoms and physical activity that is a function of the level of positive emotion a mother expressed during the negative-eliciting condition and an increase in positive emotion between the negative and positive-eliciting conditions.

To better understand the influence of physical activity on depressive symptoms, emotion, and emotion regulation, three groups were created based on the LTEQ self-reports of exercise. Mothers who met the guideline status of 150 minutes of moderate or vigorous activity were one group (N = 5), mothers who had any moderate or vigorous exercise were another group (N = 22), and mothers who had no moderate or vigorous exercise were a third group (N = 19). One-way analyses of variance were performed to examine each variable of interest with these three groups. There was a trend for a significant difference in PEB during Conflict 2 (p = .06), such that mothers who met guideline status had the highest levels of PEB, mothers who exercised a little had moderate levels of PEB, and mothers who did not exercise had lower levels of PEB. No other variables showed significant differences within the groups.

To incorporate mothers who also exercised at mild levels, groups were adjusted. Mothers in the first group reported engaging in 150 minutes of mild, moderate, or vigorous exercise (N = 17), mothers in the second group reported engaging in some mild, moderate, or vigorous exercise (N = 25), and mothers in the third group reported engaging in no exercise (N = 4). One-way analyses of variance were performed to examine each variable of interest using this grouping. There were trends for significant differences in PEB in Conflict1 and Conflict2 and the depressive symptoms composite (p < .10). When probing these specific differences, it appeared that the guideline group was significantly different than the moderate exercise group in PEB during Conflict 1 and 2 (t

= -2.23 and -2.05, p <.05) (such that the guideline group had higher PEB), and the guideline group was significantly different than the no exercise group in depressive symptoms (t = 2.14, p <.05) (such that the guideline group had lower depressive symptoms). The moderate exercise group was also significantly different than the no exercise group in depressive symptoms (t = 2.13, p < .05) such that the moderate group had lower depressive symptoms.

Table 1.

Mean Levels of Depressive Symptoms and Physical Activity Variables

Variable	Mean (Std)	Range in this sample
CES-D	8.17 (7.56)	0 - 46
BDI	7.69 (6.71)	0 - 26
EPDS	6.05 (4.18)	0 - 19
LTEQ(overall)	48.80 (68.64)	0 - 324
LTEQ Mild	5.74 (7.40)	0 - 30
LTEQ Mod	3.90 (7.14)	0 – 34
LTEQ Stren	1.36 (4.60)	0 – 30
Pedometer	7,727.68 (3,630.65)	927 – 23,748

Table 2.

Mean (SD) and Associations among ER Variables

Variable (Mean/SD)	ΔRSA	ΔNEB	ΔPEB
ΔRSA .18 (.62)	--	.14	.12
ΔNEB -.32 (.32)		--	-.15
ΔPEB .17 (16)			--

Table 3.

Correlations among Emotion Index Variables

Variable	RSA B	RSA C1	RSA C2	RSA P	NEBC1	NEBC2	NEBP	PEBC1	PEBC2	PEBP
RSA Baseline	--	.67**	.78**	.75**	.15	.02	-.14	-.10	-.10	.00
RSA Conflict1		--	.88**	.79**	-.14	-.20	-.17	-.13	-.06	.10
RSA Conflict2			--	.86**	.02	-.10	-.12	-.10	-.04	.12
RSA Positive Ex				--	-.04	-.16	-.12	-.14	-.13	.07
NEB Conflict1					--	.88**	.21	.10	-.00	.21
NEB Conflict2						--	.28	.06	-.12	-.10
NEB Pos Ex							--	-.19	-.23	-.46**
PEB Conflict1								--	.84**	.57**
PEB Confict2									--	.70**

Table 4.

Mean Levels of Emotion Indices within Segments

Variable	Mean (Std)
RSA Baseline	5.66 (1.17)
RSA Conflict1	6.20 (1.15)
RSA Conflict2	6.09 (1.18)
RSA Pos Ex	6.26 (1.17)
Proportion NEB Conflict1	.45 (.31)
Proportion NEB Conflict 2	.49 (.31)
Proportion NEB Pos Ex	.18 (.14)
Proportion PEB Conflict1	.35 (.23)
Proportion PEB Conflict 2	.30 (.20)
Proportion PEB Pos Ex	.47 (.20)

Table 5.

Correlations between Physical Activity Variables and Other Variables

	Pedometer	LTEQ
Continuous Depressive Symptoms	-.19	-.10
Depression Group	-.19	-.13
RSA Baseline	-.17	-.13
RSA Conflict1	-.29*	-.12
RSA Conflict2	-.20	-.04
RSA Pos Ex	-.16	.04
NEB Conflict1	.06	.08
NEB Conflict2	.06	-.05
NEB Pos Ex	.11	.04
PEB Conflict1	.08	.33*
PEB Conflict2	.16	.33*
PEB Pos Ex	.21	.19
ΔRSA	.08	.15
ΔNEB	-.01	.07
Δ PEB	.05	-.19

Figure 1.

Quadratic patterns of PEB and NEB in Conflict1, Conflict2, and Pos Ex.

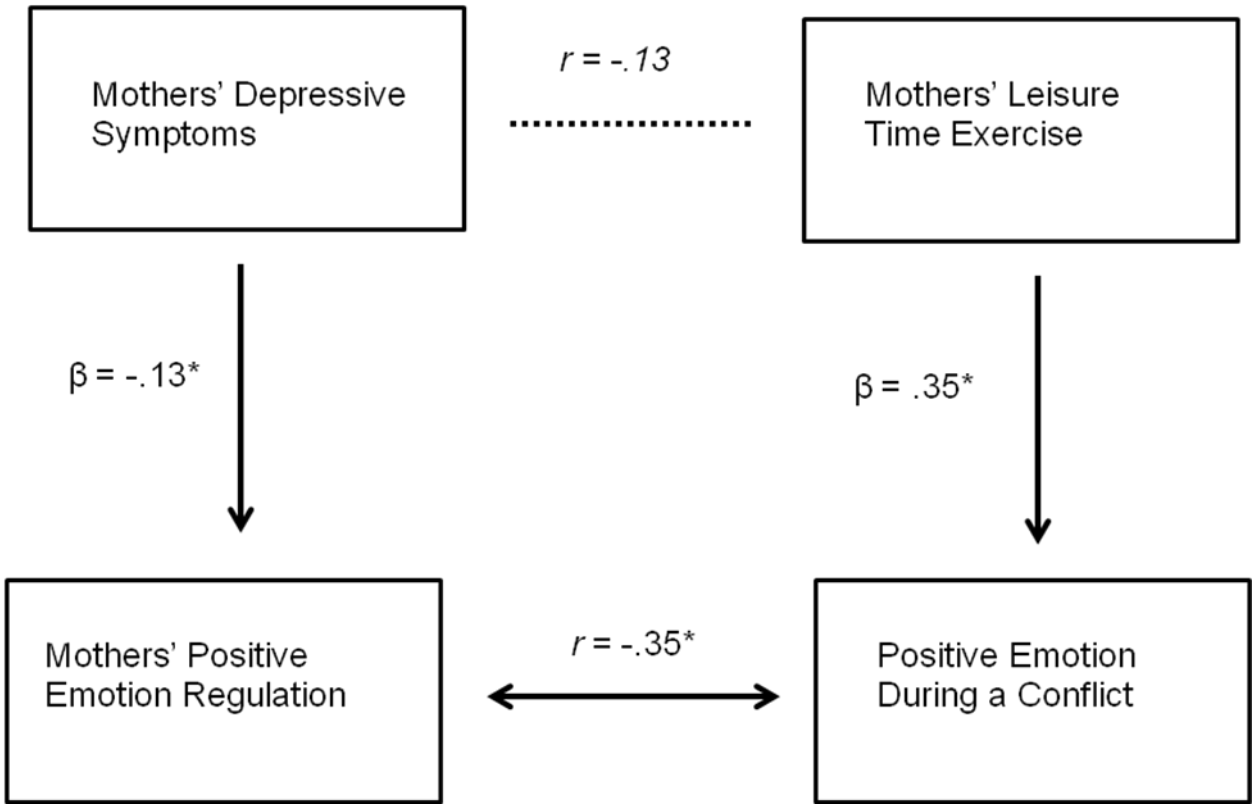

Figure 2.

Model displaying findings in the current study.

Chapter 4. DISCUSSION

To better understand factors that may ameliorate depressive symptoms and promote more positive functioning for mothers during the postpartum period, the current study sought to examine associations among depressive symptoms, behavioral and physiological indices of emotion and emotion regulation, and indices of physical activity for mothers during the postpartum period. The postpartum period is associated with increased risk for high levels of depressive symptoms, resulting in detrimental effects on mothers, partners, and infants (e.g., Goodman, 2007). The study used a paradigm with a naturalistic family interaction to mimic typical emotional exchanges at home that could be generalized to other settings and ultimately translated to interventions.

Overall, the current study confirmed the hypothesis that mothers with lower levels of depressive symptoms display a greater increase in positive expressive behavior as the emotion-eliciting properties of discussions with their partners shifted from a context that typically elicits negative emotion to one that elicits positive emotion. This finding occurred even when controlling for overall levels of emotion in the discussions, indicating that the increase was not due to differential rates of positive or negative emotion. Thus, it appears that postpartum mothers with high levels of depressive symptoms are more likely to have difficulty increasing positive emotions following a presumably stressful family interaction. Moreover, although amount of exercise was not directly related to depressive symptoms or to emotion regulation indices, mothers who exercised more during their leisure time showed more positive emotion during the Conflict discussion, suggesting that physical activity during the postpartum period may have benefits for mothers and their interactions with family members. These unexpected findings

suggest that depressive symptoms and physical activity may be indirectly related in the current sample, as opposed to being mediated by emotion regulation.

Postpartum Depressive Symptoms

Although the study sought to recruit mothers with a range of risk for depression, the overall level of depressive symptoms in the sample was relatively low. Perhaps mothers with higher levels of depressive symptoms had difficulty overcoming the challenge of bringing their families into the lab, or did not have the energy to respond to letters or requests to participate. During the postpartum period, increases in stress associated with changes in daily functioning contribute to the onset of postpartum depressive symptoms (e.g., Goodman, 2007). Mothers for whom relatively high levels of depressive symptoms have not remitted presumably have significant difficulty with the daily tasks associated with being a parent, and this might extend to organizing the family to make a visit to the laboratory for a research study.

None of the overall proportions of emotion indices in either parts of the Conflict discussion or the Positive Experiences discussion were associated with depressive symptoms. Although previous research has shown that depressed mothers display lower levels of positive emotion during family interactions (Cox et al., 1987; Field, 1995; Goodman & Brumley, 1990; Kendler et al., 2000), the current sample may not have had high enough levels of depressive symptoms to replicate these findings. Likewise, these mothers may not have had high enough levels of depressive symptoms to display significant differences in negative emotion during these discussions, particularly during the Positive Experience discussion. Many of these previous studies have examined mothers during interactions with infants, not necessarily during discussions with partners with infants present, so the behavior of mothers in the current study may differ.

Emotion Indices during Family Interactions

Given evidence suggesting that the ability to decrease negative emotion and increase positive emotion appears to be difficult for individuals with high levels of depressive symptoms (Heller et al., 2009), the current study created a paradigm designed to test these processes in postpartum mothers during typical family interactions. The paradigm was designed to elicit negative emotion and ask mothers to immediately shift to discussing positive experiences (to presumably elicit positive emotion), similar to a situation in which mothers may be arguing with partners and then immediately need to attend to their infant. This paradigm was successful in eliciting the expected patterns, on average, for mothers.

As predicted, mothers displayed relatively higher levels of negative expressive behavior (NEB), on average, during the Conflict discussion, and relatively higher levels of positive expressive behavior (PEB), on average, during the Positive Experience discussion. In addition, PEB was correlated across contexts and NEB was correlated within the conflict discussion, suggesting that mothers were relatively stable in the amount of positive and negative emotion they displayed. Moreover, PEB during the Positive Experiences discussion predicted change in NEB, and NEB during the Positive Experiences discussion predicted change in PEB. These findings collectively suggest that mothers who increased positive emotions during the Positive Experiences discussion may have been able to manage and decrease the negative emotions they displayed during the Conflict discussion (consistent with the Undoing Hypothesis), whereas mothers who were unable to become increasingly positive may have had difficulty managing negative emotions.

The current study additionally examined mothers' vagal control (indexed by RSA) during the two parts of the Conflict discussion and the Positive Experience discussion. Previous

research has shown that vagal control decreases during a stressor in the environment to allow an appropriate behavioral response, and therefore should increase when the stressor is removed (Porges, 2001). Moreover, it has been found that positive emotions subdue increased cardiovascular reactivity caused by negative emotions (Frederickson et al., 2000). Thus, it was thought that vagal control would decrease during the Conflict discussion and increase during the Positive Experiences discussion when mothers experienced higher levels of positive emotion. Although this general pattern did occur, the differences between each segment were not statistically significant.

Moreover, there were no associations between RSA and PEB or NEB, suggesting that mothers' physiological reactions were not reflective of the emotions they expressed during the discussions. This finding is consistent with a recent study that suggested that although emotion regulatory strategies were associated with RSA, facial expressions during tasks designed to elicit different emotions were not associated with RSA (Volokhov & Demaree, 2010). It appears that behavioral and physiological measures of regulation may be distinct and independent indices of the management of arousal.

Emotion Regulation and Measures of Depression

Research has shown that the experience of positive emotions following negative emotions broadens individuals' behavioral and cognitive repertoires for adaptive choices from the narrowing of repertoires that occurs with negative emotions, thus correcting or "undoing" the aftereffects of negative emotions (Frederickson, 2001; Frederickson, et al., 2000). However, individuals with depression may have difficulty enhancing positive emotion, recovering from negative emotion in response to different emotion eliciting contextual cues, or using effective

regulatory strategies overall, leading to chronic negative emotion with little variation or positive emotion (Forbes & Dahl, 2005; Gross & Munoz, 1995).

Since a goal of the current study was to examine whether mothers with varying levels of depressive symptoms used positive emotion to manage negative emotion, analyses were adjusted to examine the independent contribution of depressive symptoms to change in negative emotion and change in positive emotion, controlling for overall levels of positive and negative emotion during discussions. By controlling for levels of positive and negative emotion, effects due specifically to the rate of change in emotion could be examined. Otherwise, for example, mothers who were less negative and more positive to begin may not appear to show an increase in positive emotion between conditions.

Mothers with relatively low levels of depressive symptoms displayed greater increases in positive expressive behavior than mothers with higher levels of depressive symptoms, consistent with research suggesting that disruptions in reward processing, including deficits in the ability to use positive events to reframe situations, are reflective of individuals with depression (e.g., Rottenberg et al., 2005; Tomarken & Keener, 1998). Perhaps postpartum mothers with higher levels of depressive symptoms experience this type of difficulty during family interactions. Interestingly, depressive symptoms were not associated with a decrease in negative expressive behavior between the two discussions, suggesting that there may be a unique contribution from increasing positive emotion that may have implications for the remittance of depressive symptoms.

It is notable that the categorical measure of depressive symptoms, and not the dimensional measure, predicted increases in positive emotion despite no differences in statistical power. Perhaps there is a qualitative shift beyond a certain level of depressive symptoms after

which the impact of depression is considerably more impairing for mothers during the postpartum period. It is possible that mothers who experience depressive symptoms at this level are at risk for depression because of other factors (i.e., physical health difficulties, low SES, other psychopathology) that contribute to their impaired functioning. Alternately, these mothers may be experiencing higher levels of stress across many domains compared with other mothers, which may result in higher levels of depressive symptoms. The current findings suggest that insensitivity to environmental cues (such as family interactions) may only occur when mothers are considered at-risk for clinical diagnoses of depression and may not be present for mothers experiencing moderate to low levels of depressive symptoms.

With regard to depressive symptoms and vagal control, previous research has suggested that individuals with high levels of depressive symptoms display relatively low levels of baseline vagal control, suggesting lower capacity for regulation, than individuals with low levels of depressive symptoms (Rottenberg, 2007). In the current study, depressive symptoms were not associated with RSA in any segment, or with change in RSA across segments. It is possible that the discussion conditions did not elicit noticeable change in physiology, although change was in the expected direction. However, statistical power with appropriate covariates in the model was very low, indicating insufficient power to detect an association between vagal control and measures of depression. In addition, given that previous research examining links between RSA and depressive symptoms has mostly used clinical populations, perhaps this sample had levels of depressive symptoms that did not affect physiology.

Physical Activity and Depressive Symptoms

The current sample displayed a wide range of physical activity with an average of 7,728 steps per day and a range of leisure time activity. The Physical Activity Guidelines state that

postpartum women should engage in at least 150 minutes per week of moderate to vigorous physical activity (USDHHS, 2008), and only 5 mothers in the current sample followed these recommendations based on their self reports. Thus, the majority of mothers in the current study had relatively low levels of physical activity compared to national guidelines. One study examined 1,442 women from before pregnancy through 6 months postpartum and found that that although approximately 13% of adult women were insufficiently active (had less than 150 minutes per week of any type of leisure time physical activity) prior to pregnancy, 22% were insufficiently active 6 months postpartum (Pereira, Rifas-Shiman, Kleinman, Rich-Edwards, Peterson, & Gilman, 2007). Thus, rates of physical activity tend to be relatively lower during the postpartum period, consistent with the current sample.

It was hypothesized that higher levels of physical activity would be associated with lower levels of depressive symptoms. However, there were no significant associations between physical activity and depressive symptoms in the current sample based on the initial hypothesized associations. However, post hoc analyses that examined three exercise groups based on mothers' leisure time exercise ratings found that mothers who exercised at any level had lower levels of depressive symptoms than mothers who did not exercise at all, with mothers who met exercise guidelines displaying lowest levels of depressive symptoms. Thus, varying levels of leisure-time exercise were related to lower levels of depressive symptoms.

Previous research has found evidence suggesting that in non-pre or post-partum populations, individuals who increased physical activity showed declines in depressive symptoms, or the remittance of clinical depression over time (Camacho et al., 1001; Paffenbarger et al., 1994; Rethorst et al., 2009; Statholpulou et al., 2006). However, the current sample differs from these previous samples in several ways. Perhaps most importantly, the dosage of exercise

prescribed during these interventions was higher than the average level of physical activity observed in the current study. One study found that improvements in depressive symptoms could be seen in clinical samples as early as 5 weeks of low to moderate exercise activity three times a week for 20-60 minutes (Tkachuck & Martin, 1999). The current study only examined one week of physical activity during which mothers had relatively lower levels of exercise, and many previous studies have followed participants for several weeks with higher levels of exercise. However, it is notable that mothers who exercised did show significantly different levels of depressive symptoms than those who did not, consistent with previous research.

In addition to all of these differences between samples, the current sample was composed of mothers during the postpartum period. A few studies have examined depressive symptoms and physical activity during pregnancy. Although evidence has been found linking exercise behavior during the end of pregnancy to depressive symptoms during the postpartum period, prior depressive symptoms have been found to explain more of the variance in later depressive symptoms than physical activity (Downs et al., 2008). Future longitudinal research is needed to examine these processes. Moreover, a randomized control trial that examined exercise and depressive symptoms during the postpartum period did not find an association between exercise and the remittance of depressive symptom (Norman et al., 2010). However, the current study did find differences in mothers who exercised compared with mothers that did not, with mothers who met exercise guidelines showing the lowest levels of depressive symptoms. Perhaps during the postpartum period the links and mechanisms between physical activity and depressive symptoms are different than non-postpartum periods. More research is needed to examine more specific mechanisms and associations between depression and exercise during the postpartum period.

Physical Activity and Emotion

Mothers who reported higher levels of leisure time exercise displayed higher levels of positive expressive behavior during the Conflict discussion, consistent with previous research. In addition to a continuous association, a categorical grouping of mothers based on exercise also related to positive expressive behavior during the conflict. Mothers who met guideline status had significantly more positive expressive behavior during both parts of the conflict than mothers who had moderate or no levels of exercise. Thus, exercising at recommended levels may have a threshold effect for the concurrent display of higher levels of positive emotion during a stressor. Research has shown that individuals experience happier moods and show more positive expressions following exercise (Elavsky et al., 2005; Steinberg et al., 1998). Although some research suggests that individuals who exercise more often show lower levels of negative emotions following exercise, the current study did not find associations between negative expressive behavior and either index of physical activity. However, previous studies measured changes in emotion immediately following exercise, which may explain the different results.

It is notable that self-report leisure time exercise, and not pedometer activity, was related to positive emotion. The LTEQ is mothers' report of physical activity, presumably for the purpose of exercise (Godin & Shepard, 1985), whereas pedometer activity is thought to reflect free-living physical activity (Schneider, Crouter, & Bassett, 2004). Pedometer and LTEQ ratings were moderately associated in the current study, suggesting that although reports of leisure-time exercise were related to free-living physical activity, they were independent measures of physical activity. The current study suggests that only mothers who take time out of their day to exercise, as opposed to mothers who are naturally more active, have relatively higher levels of positive emotion during a Conflict discussion than mothers who exercise less often. It is important to

note that pedometer activity is an objective measure of activity, whereas LTEQ is self-report, and therefore subject to biases. It is possible that mothers who tend to be more positive remember exercising more often than they do, or they are over-reporting due to demand characteristics.

With regard to emotion regulation and physical activity, changes in positive and negative expressive behavior were not related to either index of physical activity. The current study was not consistent with prior findings that suggest that exercise is associated with decreases in negative emotion and increases in positive emotion (emotion regulation) (Berger & Motl, 2000), at least when measured during a shift in emotion-eliciting discussions with partners for postpartum mothers. Although related, overall levels of emotion and change in level of emotion are thought to be conceptually distinct constructs that represent different processes.

Theories of emotion regulation suggest that emotion regulation involves maintenance and enhancement of an emotion as well as inhibition and reduction of emotions (Thompson, 1994). Thus, emotion activation must occur before change in emotion (i.e., emotion regulation) can be identified (Cole et al., 2004). However, this process occurs at a different temporal level than that measured in the current study. Emotions occur rapidly, lasting only seconds, whereas the current study measured emotion levels in the aggregate. Although emotion activation and emotion regulation are conceptually distinct, it is unclear how to differentiate the processes methodologically. Furthermore, current theorists are proposing that emotion regulation is a component of emotion activation and, therefore, may not be clearly separable, conceptually, from emotions (Thompson & Goodman, 2010). Thus, although the current study found that physical activity was related to overall positive emotion and not to change in positive emotion, it remains unclear whether these processes are truly distinct as measured in the current study.

However, based on measurement and definitions in the current study, overall levels of positive emotion during the Conflict discussion may reflect mothers' typical levels of positivity during stressful interactions with partners and infants. Levels of positive emotion were highly correlated across Conflict segments, suggesting stability. Thus, leisure time exercise appears to be associated with more trait-like displays of positive emotion during stressful situations rather than measures of change in emotion in response to immediate environmental cues. In day-to-day life, perhaps mothers who exercise at guideline recommendations are able have disagreements with partners while showing higher levels of positive emotion than mothers who exercise less than guideline recommendations. These mothers additionally appear to show relatively lower levels of depressive symptoms than mothers who do not meet guidelines or exercise at all.

With regard to physical activity and vagal control, previous research has shown that higher levels of physical activity are associated with higher levels of baseline vagal control (Buch et al., 2002). The current study found that lower RSA during the first half of the conflict was associated with higher pedometer activity. However, the current study did not find any other associations between physical activity and RSA in any other segment, or change in RSA (vagal control), thought to be reflective of physiological regulation. Thus, the one significant correlation between RSA and physical activity is likely due to chance. Therefore, it appears that in the current sample, physical activity does not reliably relate to physiological response or regulation during family discussions.

Since overall levels of physical activity were relatively low in the current sample, it is possible that physiological effects may not be observed at this level of activity. No previous research to date has examined the link between vagal control and physical activity during the

postpartum period, so it may be that during this period, associations are different from non-postpartum women.

Limitations and Future Studies

The current study had several limitations. First, the sample was composed of a relatively small number of middle class, Caucasian women from a predominantly rural area. These findings may be different when examining women of different ethnicities, SES levels, and from different geographic regions. Second, the mean level of depressive symptoms was relatively low, so examining samples with clinical levels of depression would possibly find different results. Third, the measures in the current study were concurrent; therefore causal associations cannot be determined. Fourth, physical activity levels were observed to be relatively low, and mothers who follow the Physical Activity Guidelines may have additional benefits associated with exercise. In the current study, the lack of expected findings is quite likely due, in part, to many of these limitations.

To address these limitations, future studies should examine postpartum mothers with clinical levels of depression. This may be achieved by 1) recruiting mothers through a clinical sample as opposed to a community sample, 2) performing visits in the home (instead of asking mothers to bring families to the laboratory), and 3) assessing for depression during pregnancy, which increases the risk that mothers will experience postpartum depression. In addition, future studies should also include mothers with a wider range of physical activity. Mothers should be screened prior to the study to determine whether they meet Physical Activity Guidelines. Longitudinal research would be valuable to examine associations among depressive symptoms, emotion regulation, and physical activity over time, possibly using a randomized control trial of increasing levels of physical activity for some mothers.

Future research would likely benefit from measuring emotion regulation in a way more consistent with conceptual definitions. Given the rapid temporal nature of emotions, and therefore emotion regulation, perhaps measuring emotions on a second-by-second basis and using a time-series analysis would more effectively pinpoint the processes of emotion activation and regulation. The current study measured emotions and indices of emotion regulation in the aggregate, but emotion activation and regulation are dynamic processes. Micro-level analyses may be more appropriate to disentangle these processes. It is additionally possible that emotions and emotion regulation processes are not conceptually distinct. In that case, the current study would suggest that perhaps depressive symptoms and physical activity are related through a latent variable, conceptualized and measured as both level and change in positive emotion (consistent with Figure 2). More research on these processes is needed to determine how to best understand emotion and emotion regulation, and associations with depressive symptoms and physical activity during the postpartum period.

The current study suggests that mothers during the postpartum period who display an increase in positive emotion following a stressor and report more leisure time exercise have lower levels of depressive symptoms. Previous research has tended to focus on negative aspects of postpartum depression in mothers, but the current project focused on promoting positive functioning in mothers through the use of positive emotion and exercise, two possible factors that have the potential to ameliorate postpartum depressive symptoms. The current study created a paradigm to successfully test how mothers use positive emotions to manage negative emotions. Findings from this study contribute ideas for future research to pinpoint specific factors that may ameliorate postpartum depressive symptoms and promote more positive functioning for mothers and families during the postpartum period.

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PROFESSIONAL HONORS

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National Dean's List	2008
Dean's List, Cornell University	2002-2005
Human Ecology Research Association Award, Cornell University	2003

PEER REVIEWED ORIGINAL RESEARCH

Hutt, R. L., Buss, K. A., & Kiel, E. J. (2012). Moms matter: Caregiver protective behavior, toddler fear and sadness, and toddler cortisol reactivity in novel contexts. *Infancy*, DOI: 10.1111/j.1532-7078.2012.00141.x

Hutt, R.L., Wang, Q. & Evans, G.W. (2009). Parent-youth interactive exchanges and adolescent socioemotional development. *Social Development, 18*, 785-797.

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PRESENTATIONS

Hutt, R. L. & Moore, G. A. (2013, April). *Postpartum mothers' physical activity, depressive symptoms, and positive emotion during partner discussions.* Poster presented at the Biennial Meeting of the Society for Research in Child Development, Seattle, WA.

Hutt, R. L., Moore, G. A, & Mammen, M. A. (2012, June). *Mothers' physical activity and regulation during the postpartum period*. Poster presented at the XVIIIth Biennial International Conference for Infant Studies, Minneapolis, MN.