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The Dynamics of Parenting Self-Efficacy in Mothers of Infants: An Ecological Momentary Assessment Study
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The Dynamics of Parenting Self-Efficacy in Mothers of Infants: An Ecological Momentary Assessment Study

By

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M.A., Emory University, 2017
B.A., Vanderbilt University, 2012

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An abstract of
A dissertation submitted to the Faculty of the
James T. Laney School of Graduate Studies of Emory University
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Abstract

The Dynamics of Parenting Self-Efficacy in Mothers of Infants: An Ecological Momentary Assessment Study

By Hannah F.M. Simon

Parenting self-efficacy (PSE) is defined as the beliefs a parent holds about his or her capabilities to organize and execute the tasks related to parenting a child, and has been called the "final common pathway" in the determination of effective parenting (Teti & Gelfand, 1991). PSE is especially important among first time mothers of infants, given that the transition to parenthood is a major developmental life event that involves many challenges to one's sense of efficacy. The current study therefore investigated three overall aims in first time mothers of infants aged 4 to 9 months (n = 155). First, we empirically tested the theoretical notions of how maternal (symptoms of depression and anxiety, perceived stress, social support, and sleep) and infant (temperament) characteristics are associated with perceptions of PSE cross-sectionally. Second, we take a novel approach to studying PSE (ecological momentary assessment) by examining it as a dynamic construct. Third, we examine how changes in a subset of maternal characteristics (symptoms of depression and anxiety, positive and negative mood, and perceived stress) are related to PSE in the moment and over time, using an intensive longitudinal design. The overall aim of these latter two aspects of the study was to develop a more nuanced understanding of how maternal affective states may be associated with parenting beliefs by examining their associations in the moment and over time. We found significant cross-sectional associations between PSE and maternal symptoms of depression, stress, and the negative affect and effortful control domains of infant temperament. The EMA portion of the current study yielded support for PSE as a dynamic construct, such that PSE increased over the course of the day and over the days of the study. Variability in PSE was significantly associated with intrapersonal fluctuations in symptoms of depression and anxiety, positive and negative mood, and perceived stress in the moment and over time.

Keywords: parenting self-efficacy, depression, infancy

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The Dynamics of Parenting Self-Efficacy in Mothers of Infants: An Ecological Momentary Assessment Study

Individuals' beliefs in their efficacy to regulate their own functions and to exercise control over events that affect their lives is thought to be the most central and pervasive mechanism of human agency (Bandura, 1997). Self-efficacy is defined as an individual's belief in his or her ability to successfully perform a given task (Kohlhoff & Barnett, 2013). The concept of self-efficacy has been extended to several domains, including parenting. Parenting self-efficacy (PSE) is defined as the beliefs a parent holds about his or her capabilities to organize and execute the tasks related to parenting a child, and has been called the "final common pathway" in the determination of effective parenting (Teti & Gelfand, 1991). Self-efficacy beliefs in the context of parenting, particularly among first time mothers of infants, are especially important given that the transition to parenthood is a major developmental life event that involves many challenges to one's sense of efficacy, including demanding time and energy requirements, developing competence in new tasks related to parenting, and providing care and nurturance to one's infant.

PSE and Parenting

As suggested by the concept of parenting self-efficacy (PSE) as the "final common pathway" to effective parenting (Teti & Gelfand, 1991), PSE has been found to be associated with a broad array of parenting behaviors, with parenting qualities, and with parenting competence (Coleman & Karraker, 1998; Coleman & Karraker, 2000; Jones & Prinz, 2005). Specifically among mothers of infants, PSE has been found to be associated with observed competence in positive parenting characteristics, e.g., sensitivity and warmth, and with negative parenting characteristics, e.g., flatness of affect, disengagement, and anger (Teti & Gelfand, 1991). Overall, findings on associations between PSE and parenting competence are interpreted as reflecting the idea that parents with high PSE may have more confidence in acquiring and exercising effective parenting skills. In contrast, parents with low PSE, who believe that they do not have the ability to parent successfully, may give up more easily in the face of the many common challenges that face parents, may not put their knowledge of parenting into action, or may

become emotionally aroused in ways that interfere with effective parenting (Jones & Prinz, 2005). Consistent with this understanding, parents' low levels of PSE have been found to be related to their poor persistence and follow-through in parenting tasks (Johnston & Mash, 1989). Overall, low PSE being associated with a number of maladaptive parenting behaviors motivates the need to understand factors that may be associated with low PSE in order to better inform interventions to enhance PSE.

PSE and Child Outcomes

In addition to associations with maladaptive parenting, PSE has been found to be associated with child adjustment and other developmental outcomes (Teti & Gelfand, 1991). In their review of associations between PSE and child adjustment, Jones and Prinz (2005) found moderate effect sizes for associations between PSE and independent reports of child behaviors, including emotional and behavioral problems (e.g. anxiety), socio-emotional functioning, and child academic achievement, across child ages and sample characteristics. For example, Coleman and Karraker (2003) found a significant relationship between PSE and toddler adjustment, with higher maternal PSE predicting higher child enthusiasm, compliance, affection, and lower child avoidance and negativity. Among mothers of infants, low PSE has been found to be associated with higher observed infant negative emotionality (Troutman et al., 2012) and with lower infant signaling capacity during mother-infant interactions (Bohlin & Hagekull, 1987). Support for the relationship between PSE and child outcomes further emphasizes the importance of better understanding correlates of PSE (Jones & Prinz, 2005).

Correlates of PSE

Given the important role of PSE in parenting competence and child outcomes, research has focused on what maternal and infant characteristics may be associated with mothers' PSE. Among maternal characteristics, researchers have focused primarily on associations between PSE and depression and (to a lesser extent) anxiety, perceived stress, social support, and sleep quality.

One reason to be concerned about these characteristics of mothers, which justifies pursuing questions about them as correlates of PSE, is that researchers find these characteristics to be associated

with qualities of parenting. For example, a qualitative review of depression and parenting of infants, specifically, found that depressive symptoms in mothers were associated with their displaying less sensitivity and responsivity during interactions with their infants and compromised caregiving in the context of activities such as feeding practices, sleep routines, and safety practices (Field, 2010). Anxiety in mothers of infants is also associated with parenting qualities. Specifically, a review of anxiety in the postnatal period found considerable evidence that anxiety is negatively associated with positive parenting behaviors, desirable mother-infant interactions, and bonding (Goodman et al., 2016). In addition, there is evidence that comorbid depression and anxiety is associated with parenting difficulties in mothers of infants. Researchers find that mothers of infants with depression that is comorbid with high anxiety, relative to depression alone, display lower quality parenting styles (Azak & Raeder, 2013), including spending less time smiling, showing exaggerated faces, gameplaying and initiation (Field et al., 2005). Beyond depression and anxiety, mothers' greater stress and lower social support are associated with their lower quality of interactions with their infants during early infancy (Crnic et al., 1984) and with less sensitive parenting (Goldstein et al., 1996). Finally, mothers' lower sleep quality (i.e., shorter, later, and more variable sleep, taking longer to fall asleep, and higher perceived sleep problems) is associated with more dysfunctional parenting (McQuillan et al., 2019); further, mothers' higher insomnia scores and greater sleep disturbances (due to tending to infants) are associated with mothers' more negative perceptions of the mother-infant relationship and more negative subjective experiences of attachment to their infants (Tikotzky, 2016; Tikotzky et al., 2012).

Among infant characteristics, temperament has received the most attention as a correlate of PSE. Similar to the maternal characteristics, justification for considering infant temperament as a correlate of PSE also comes from findings that aspects of infant temperament have been found to be associated with parenting behaviors. Researchers find associations between negative emotionality (NE; i.e., one of the core constructs of temperament) and negative parenting (Bridgett et al., 2009); a meta-analysis found an overall association between NE and less supportive parenting (Paulussen-Hoogeboom et al., 2007). In

addition, infants who experience regulatory difficulties (e.g., effortful control, another core construct of temperament) have been found to be at greatest risk for experiencing greater maternal negative parenting (Bridgett et al., 2009). In toddlers, greater self-regulated compliance, also conceptualized as an index of effortful control, has been found to be associated with greater maternal sensitivity and warmth (Feldman & Klein, 2003). Few studies have examined associations between surgency, another core construct of temperament, and parenting. However, Kochanska et al. (2004) found that greater infant joy, an index of the surgency or positive affect domain of temperament, was associated with mothers' observed greater responsiveness.

Overall, these links with quality of parenting support the importance of understanding the extent to which these maternal (depression/anxiety, perceived stress, social support, and sleep) and infant (temperament) characteristics are related to PSE. In the next section, we review findings that support those associations and also note shortcomings of the literature, which we address in the current study.

Maternal Characteristics

PSE and depression and anxiety. PSE beliefs are especially of concern in the context of depression, given well-established links between depression and cognitive distortions, dysfunctional beliefs, and information-processing biases (Beck, 2008), and in the context of anxiety, given links between anxiety and negative thinking orientations and doubts about competence, capability, and fear of failure (Breitholtz et al., 1999). That is, cognitive and affective symptoms of depression and anxiety may lead mothers to doubt their parenting abilities. In terms of empirical support for this theory, studies have mainly focused on depression, relative to anxiety. PSE has been found to be consistently associated with depression in mothers, with a meta-analytic review revealing an overall negative, moderate effect for the association between depression and PSE (Simon & Goodman, 2018; unpublished manuscript). The literature reporting on associations between PSE and anxiety is much smaller than the literature on PSE and depression. In a few published papers, researchers report having found that mothers' lower PSE is associated with their higher levels of anxiety; however one of these studies sampled women hospitalized

for depression or anxiety (Kohlhoff & Barnett, 2013) and the other sampled mothers of children with autism (Rezendez & Scarpa, 2011). Among first time mothers of infants, Porter and Hsu (2003) found an association between mothers' PSE and their anxiety at one month postpartum, but not at three months. Thus, even among cross-sectional study designs, whose limitations we review later, research reliably links mothers' depression and their PSE, but has not adequately addressed the question of to what extent anxiety in mothers may be associated with their lower PSE beliefs.

Perceived Stress. Theories of self-efficacy and stress suggest that the perception or subjective experience of stress, rather than more objective measures of stress exposures (such as stressful life events checklists), influences one's sense of efficacy. As such, the current study focused on subjective reaction states of stress (Harkness & Monroe, 2016), or perceived stress. A review of stress and PSE emphasized that while there is strong theoretical rationale for expecting an association between stress and PSE, direct evidence of this association is somewhat limited (Crnic & Ross, 2017). In first time mothers of infants, PSE has been found to be significantly, negatively associated with perceived stress (Ngai et al., 2010; Reece & Harkless, 1998). However, these studies of PSE and perceived stress are limited in that they measured stress over the previous year (Ngai et al., 2010) and month (Reece & Harkless, 1998). This approach, particularly of assessing stress over the past year, is especially problematic for mothers of infants, as it may encompass events prior to the babies' birth. The current study builds on these findings on perceived stress by examining cross-sectional associations between PSE and stress in the past week, as well as dynamically (see below), by examining perceived stress and PSE in the moment and over time.

PSE and Social Support. Bandura (1989) theorized that social support processes such as social persuasion and verbal encouragement contribute to one's self-efficacy. This theory has considerable empirical support. Social support has been found to be significantly associated with PSE across diverse samples (Gao et al., 2014; Izzo et al., 2000; Suzuki et al., 2009), including among first time mothers of infants (Haslam et al., 2006; Leahy-Warren et al., 2012). PSE has also been found to mediate the association between maternal social support and postnatal depression (Cutrona & Troutman, 1986;

Haslam et al., 2006). However, findings in mothers of infants have come from studies of very young infants (i.e., four to six weeks; Haslam et al., 2006; Leahy-Warren et al., 2011). This is a concerning limitation because PSE beliefs are theorized to be influenced by social processes regardless of the child's age. Thus, it is essential to build on the literature that examined PSE and social support in mothers of very young infants in order to test whether the association holds true through later infancy.

PSE and Mothers' Sleep Quality. Mothers of infants report significant sleep disturbances, such as being woken up throughout the night, getting less than six hours of sleep, and feeling that their baby's sleep patterns prevented them from getting sufficient sleep (Dennis & Ross, 2005). Yet, despite sleep problems being common in mothers of infants, and the associations researchers find between sleep and depression and parenting, we found few published papers on mothers' sleep and PSE. The few studies we found all focused on one particular aspect of sleep, i.e. fatigue. Mothers' greater fatigue is associated with their lower PSE (Dunning & Giallo, 2012; Lesniowska et al. 2016), although one study found that fatigue was associated with PSE only in the added presence of high depression (Wade et al. 2012). Studies having exclusively examined fatigue in relation to PSE are limiting given evidence that aspects of sleep quality beyond fatigue are also associated with parenting. As reviewed earlier, multiple aspects of maternal sleep in the postnatal period are associated with mothers' parenting difficulties in terms the mother-infant relationship and attachment qualities. Therefore, the current study builds on these findings by examining multiple dimensions of sleep quality in first-time mothers of infants in relation to PSE.

Infant Characteristics

Infant Temperament. Among infant characteristics, temperament, a relatively stable quality of infants, has received the most attention as a correlate of PSE. Infant temperament is important in this regard given that PSE is theorized to be influenced by mothers' experiences with their infant; indeed, interactions with their infants are the primary experiences that determine mothers' feelings of parenting efficacy (Goldberg, 1977). Rothbart (1981) provides theoretical bases of infant temperament, which is defined as constitutionally based individual differences in reactivity and self-regulation (Gartstein &

Rothbart, 2003). Research on the measurement of infant temperament has led to the development of three broad, empirically derived domains of temperament: negative affect, surgency (positive affect) and effortful control (Gartstein & Rothbart, 2003; Putnam et al., 2014). However, research on infant temperament and PSE is limited in that the only published papers we found to have examined mothers' PSE and their infants' temperament reported on one aspect of temperament, even though temperament is a multi-faceted construct. Specifically, researchers report finding that mothers' lower PSE is associated with their perception of their infants' (Cutrona & Troutman, 1986) and toddlers'(Gross et al., 1994) temperament as more difficult or as higher in temperament negative affectivity, both at infant ages one and three months (Porter & Hsu, 2003). Although it has not yet been tested empirically, theory of infant temperament suggest that more adaptable or sociable children would elicit warm and responsive parenting (Putnam et al., 2002). Given this theory and associations between the three domains of temperament and parenting, we expect that PSE may also be associated with surgency and effortful control domains of temperament. Thus, the current study builds on the extensive support for a three-factor model of infant temperament by examining associations between PSE and all three dimensions of infant temperament: surgency, negative affect, and effortful control.

Infant Sex. In terms of other infant characteristics, the literature did not provide a basis to expect differences based on infant sex on any of the characteristics we examined. Previous studies of PSE in infancy found no significant main effect of infant sex (Hudson et al., 2001) and a paper evaluating the psychometric properties of the Parenting Sense of Competence scale, which we used in the current study, also did not find a significant effect of child sex (Rogers & Matthews, 2004). In the current study, we examine potential infant sex differences descriptively.

Summary

In summary, theory and empirical studies provide some support for associations among PSE and mothers' symptoms of depression and anxiety, perceived stress, social support, sleep quality, and infant negative temperament. The current study adds to this literature by examining the gaps discussed above in

these cross-sectional associations between PSE and maternal and infant characteristics, thereby extending findings related to what extent maternal and infant characteristics may be associated with PSE among mothers of infants.

From Cross-Sectional Associations with PSE to the Dynamics of PSE

Despite the justification for better understanding the cross-sectional associations between PSE and the constructs we reviewed, it is essential to also note limitations to the approach of examining correlates of PSE with cross-sectional associations and to address those limitations with alternative study designs. In terms of limitations, it is particularly essential to note that theory of self-efficacy posits that self-efficacy is a dynamic construct, one that is modifiable in relation to changing demands, situational contexts, and individual processes (Bandura, 1989). Yet, few studies of PSE in mothers of infants have tested empirically this notion of PSE as a dynamic construct. Rather, published studies have largely employed a single measure of PSE, with the assumption that it is stable, despite Bandura's clear statement that self-efficacy beliefs are a dynamic construct (Bandura, 1989).

There are a few exceptions to the typical approach within PSE studies of only measuring PSE one time. First, we found a few studies that measured PSE longitudinally among mothers of infants. Studies that have administered a measure of PSE at least twice in a longitudinal design have done so early in infancy, i.e. six weeks and three months of age (Gao et al., 2014), one and three months of age (Porter & Hsu, 2003), and at four, eight, 12 and 16 weeks of age (Hudson et al., 2001). In all three of these studies, PSE increased significantly across the timepoints measured. However, these studies are limited in terms of understanding PSE as a dynamic construct in that they examined PSE early in infancy exclusively, used single measurement at each timepoint, and assessed PSE across relatively wide time intervals.

The second exception we found to the typical approach within PSE studies of only measuring PSE one time was studies of the test-retest reliability of the PSE measures. A systematic review of self-report measures of PSE found that although agreement between the two scores was considered to be

adequate for 47% of the PSE self-report measures, 32% of them did not mention test-retest reliability and for 21% the information was inadequate or insufficient (Wittkowski et al., 2017). This finding, that 53% of self-report measures that have been used to assess PSE report no or inadequate information on their stability, suggests that more research is needed to assess the overall stability of PSE as a construct.

In summary, neither the longitudinal studies nor the reports of test-retest reliability inform PSE as a dynamic construct. That is, they provide no information on how PSE may fluctuate in mothers of older infants, or over the course of the day or from day to day. Thus, the current study, in addition to addressing limitations within the cross-sectional approach, aimed to test support for this essential theoretical assumption – that PSE is a dynamic, rather than a stable construct using a more fine grained approach to examine fluctuations in PSE over the course of the day and week.

Further, if PSE is, indeed, dynamic over the course of the day and week, then a single measurement (i.e. the typical approach with cross-sectional studies) may represent a parent's sense of efficacy at that moment and may not accurately represent a mother's sense of efficacy at what might be considered a trait level. For example, Salonen et al. (2009) measured PSE while mothers were still in the hospital after giving birth, and posited that the protective setting of the hospital may have caused them to overestimate their abilities. As demonstrated by this example, measurement of PSE at one or two points in time may not capture the variability of self-efficacy or take into account momentary factors that may dynamically influence shifts in mothers' sense of PSE, such as momentary fluctuations in depression/anxiety symptoms, mood, or stress. That is, study designs that rely on a single measurement of PSE preclude the opportunity to capture these potential dynamic changes and we designed the current study to address these concerns.

Overall, the literature on correlates of PSE is limited given the theory of PSE as a dynamic construct and yet, the majority studies of PSE having relied on cross-sectional, correlational designs. Taken together, this imposes a major limitation of being able to address the extent to which changes in purported correlates might be related to changes in PSE. The current study further aims to extend cross-

sectional associations by also examining PSE as a dynamic construct and to test whether fluctuations in correlates of PSE are associated with dynamic changes in PSE.

Maternal Depression and Anxiety

In particular, the well-replicated finding of lower PSE being associated with higher depressive (and to a lesser degree, anxiety) symptom levels leave unanswered the essential questions of to what extent this association holds in the moment and over time. That is, in the moment, are fluctuations in maternal symptoms of depression and anxiety associated with fluctuations in PSE? The current study addresses this gap by measuring PSE along with depression/anxiety and other purported correlates throughout a day and over the course of a week, allowing us to assess the dynamics of PSE and of its relations with other variables. By investigating these associations over time and in the context of mothers' daily lives, we aim to gain a more nuanced understanding of how depression and anxiety, and other purported correlates (as reviewed below) might be dynamically associated with PSE beliefs. For this purpose, we consider depression and anxiety together, as a reflection of distress. Although depression is unique from anxiety in terms of low positive affect, depression and anxiety are similar in terms of high negative affect (Clark & Watson, 1991). Further, findings of comorbid depression and anxiety among mothers in the postnatal period suggest the importance of assessing mothers for broader indicators of distress, rather than depression alone (Miller et al., 2006).

Maternal Mood

Bandura's identification of affect as a central component in the determination of self-efficacy beliefs (Bandura, 1982) and extended to our conceptualization of PSE beliefs, suggests the importance of considering the role of mothers' momentary changes in affective states and/or mood (positive and negative affect) on PSE. Yet, in our review of PSE and maternal depression (Simon & Goodman, 2017), we found no published papers that reported an empirical examination of the role of affective states and/or

overall mood (positive and negative affect), other than as a symptom of depression and anxiety, in relation to PSE.

In the current study, we use the conceptualization of mood put forth by Tellegen et al. (1999), which characterizes mood as two independent affective components: positive affect (positive emotional states such as feeling active, delighted, interested, and enthusiastic) and negative affect (aversive emotional states such as feeling upset, angry, or guilty). Affective states have been found to be associated with individuals' judgements of their efficacy (Bandura et al., 2003), and experimental manipulation of mood has been shown to have large, significant effects on self-efficacy across a number of domains (Kavanagh & Bower, 1985). More specific to the concerns of the current study, we found some support for mothers' mood in the postnatal time period playing a role in their beliefs about parenting. Specifically, a study of first time mothers found that postnatal mood accounted for a significant proportion of variance in mothers' feelings of adequacy as a mother and feelings about caretaking (Fleming et al., 1988). These findings suggest that mood plays a significant role in the determination of self-efficacy beliefs, yet we found no published studies of mood in relation to PSE and certainly not of dynamic fluctuations in mood as predictors of fluctuations in PSE. The current study addresses this gap in the literature on PSE by examining how changes in mood, both positive and negative, may be associated with changes in PSE beliefs over the course of everyday experiences in the lives of women with infants.

Perceived Stress

As discussed above, theories of self-efficacy and stress suggest that perceived stress may be dynamically associated with PSE. Research has demonstrated cross-sectional associations between PSE and perceived stress, but these findings are limited in that they have relied on single measurements and leave unanswered essential questions of the extent of this association in the moment and over time. In line with this, a review of stress and PSE called for the need for future research to examine this association in a way that allows for a more nuanced and specific understanding of how perceived stress may be associated with PSE (Crnic & Ross, 2017). The current study heeds this call and builds on cross-sectional

findings by examining perceived stress and PSE in the moment and over time and in ecologically valid settings.

Summary

The current study aimed first, to address important gaps in knowledge of cross-sectional associations between PSE and a set of strongly theory- and empirically justified potential correlates, and second, to provide empirical support for PSE as a dynamic construct, and third, to examine whether and how variability in PSE is associated with variability in specific maternal characteristics (symptoms of depression and anxiety, positive and negative mood, and perceived stress) using a novel methodological approach.

PSE in First Time Mothers of Infants

For several reasons, we addressed our aims in first time mothers. PSE in first time mothers may be especially important given that the transition to parenthood is a major developmental life event that involves many challenges to one's sense of efficacy, including developing a relationship with the infant, learning new tasks associated with caring for a baby and developing competence in these caregiving tasks (Mercer, 2004), as well as learning about infant's development and individual characteristics (Pridham & Chang, 1992). In addition, researchers find that greater experience in and knowledge of parenting are associated with higher PSE (Coleman & Karraker, 2000; Conrad et al., 1992); specifically, multiparity has been found to be associated with higher PSE (Bryanton et al., 2008). This finding is in line with theory of self-efficacy (Bandura, 1989), which posits that mastery experiences are significant sources of self-efficacy beliefs. By studying first time mothers, we were able to examine PSE beliefs that have not been influenced by previous experiences of parenting one's own child.

In another design decision, we chose to focus on parents of infants. Parenting is thought to be at its most intense and the demands of parenting are often greatest during infancy, relative to parenting of

older children (Bornstein, 1995). Therefore, understanding these beliefs early on may be especially important. Consistent with this idea, the majority of research on PSE has studied mothers of infants.

Within the time period of infancy, we chose to focus on mothers of infants essentially in the middle of their first year of life, i.e., between the ages of four and nine months. First, we chose to exclude mothers of infants between the ages of birth and three months, given the many, and rapidly shifting changes in demands on new mothers and in infants' physical and social development (Lightfoot et al., 2005; Rochat, 2001). Once mothers and infants have gone through these rapid developmental changes and reach approximately four months, infant care and parenting tasks may seem somewhat more familiar and predictable (Pridham & Chang, 1992). This allows us to examine what maternal and infant characteristics may influence PSE as mothers become more acquainted with their infants and with their roles as mothers. Second, we excluded infants older than nine months due to significant new parenting challenges related to developmental changes that typically occur around this age, including infants' beginning to crawl and stand with assistance (Lightfoot et al., 2005) as well as social referencing, joint attention, gaze following and asking for help (Rochat, 2001). The developmental changes that occur in babies beginning at around nine months may present mothers with a new set of challenges that may confound our findings, as we aim to examine PSE in mothers of infants within similar developmental stages.

Further, we tested our study aims on mothers, rather than fathers given that mothers face unique challenges in the postnatal period, such as hormonal changes after birth, weight loss, breast feeding, and gender-specific role expectations (Areias et al., 1996) that may affect their sense of parenting efficacy. Moreover, women experience depression, both in terms of diagnoses and elevated symptom levels, at twice the rate of men (Blazer et al., 1994; Weissman et al., 1996). In the postnatal period, depression and anxiety are common in mothers; nearly 20% of women have a depressive episode postnatally (Gavin et al., 2005) while an estimated 8.5% of women experience one or more anxiety disorders in the postnatal period (Goodman et al., 2016).

The Current Study

The current study is innovative in three ways. First, we empirically test the theoretical notions of how maternal (symptoms of depression and anxiety, perceived stress, social support, sleep, and mood) and infant (temperament) characteristics are associated with perceptions of PSE cross-sectionally. Second, we take a novel approach to studying PSE by examining it as a dynamic construct. Third, we examine how changes in a subset of maternal characteristics (symptoms of depression and anxiety, positive and negative mood, and perceived stress) are related to PSE in the moment and over time, using an intensive longitudinal design. The overall aim of these latter two aspects of the study was to develop a more nuanced understanding of how maternal affective states may be associated with parenting beliefs by examining their associations in the moment and over time.

As such, the current study expands on published findings in several ways. First, the majority of the reviewed studies relied on observational (lab- or home-based) measurements of parenting that involved discrete, brief amounts of time and were typically in one context (play). We add to the typical approach by taking an ecologically valid approach, using novel, mobile phone-based methodology to sample mothers' reports of their affective states and their parenting beliefs in the moment, as they go about their everyday lives. Second, reviewed studies typically relied on correlations between (a) summary scores capturing observed parenting qualities over a discrete period of observation and (b) depression symptom levels typically measured just prior to the observations, and typically having asked women to reflect on their symptom severity levels over past week or past two-weeks. Although we attempt to expand on findings from such studies, using their same approach, in contrast to these two design features, we add to the literature by also investigating how (a) depressive and anxiety symptom levels, (b) maternal positive mood (c) maternal negative mood, and (d) maternal perceived stress in the moment are associated with PSE in the moment.

Specific Aim One

Examine associations between parenting self-efficacy and symptoms of depression in first time mothers of infants. Although this is a well-replicated finding, as reviewed above, we thought it was essential to test whether we would replicate this finding at baseline among women whom we further studied in terms of the dynamics of PSE and its correlates. Extend these findings on parenting self-efficacy and symptoms of depression to also examine the potential cross-sectional association between parenting self-efficacy and symptoms of anxiety in first time mothers of infants aged four to nine months.

Build on and extend cross-sectional findings of relationships among parenting self-efficacy and an additional set of maternal characteristics and one infant characteristic: maternal stress, multiple dimensions of sleep quality, perceived social support, and three domains of infant temperament, among first time mothers of infants aged four to nine months.

Hypothesis 1A) At baseline, parenting self-efficacy will be significantly, negatively associated with symptoms of depression and of anxiety.

Hypothesis 1B) At baseline, parenting self-efficacy will be significantly, negatively associated with mothers' stress and sleep difficulties, and significantly positively associated with perceived social support. At baseline, parenting self-efficacy will be significantly, negatively correlated with the negative affect dimension of infant temperament and significantly positively correlated with the surgency and effortful control dimensions of infant temperament.

Specific Aim Two

Stability of parenting self-efficacy: Assess the overall stability of parenting self-efficacy beliefs among mothers of infants, relative to fluctuations within- and across days.

Hypothesis 2) We hypothesize that parenting self-efficacy, measured multiple times over the course of the day and days of a week, will be variable over the course of the day and week, given theory of self-efficacy as a dynamic construct that may change in relation to changing demands, situational contexts, and individual processes (Bandura, 1989).

Specific Aim Three

Relationship between parenting self-efficacy and depression and anxiety: Examine whether variability in parenting self-efficacy is associated with variations in symptoms of depression and anxiety (considered together, as an index of distress) within and across days among mothers of infants.

Hypothesis 3a) Variations in parenting self-efficacy will be associated with variations in symptoms of depression and anxiety, such that changes in parenting self-efficacy will be associated with changes in symptoms of depression and anxiety within (Hypothesis 3b) and across (Hypothesis 3c) days.

Specific Aim Four

Relationship of parenting self-efficacy and Positive Mood: Evaluate the extent to which, among mothers of infants, variations in parenting self-efficacy beliefs are related to variations in positive mood.

Hypotheses 4a) Variations in parenting self-efficacy will be associated with variations in daily mood, such that, across moments in the day (Hypothesis 4b) and across days (Hypothesis 4c), parenting self-efficacy will be higher in relation to more positive mood.

Specific Aim Five

Relationship of parenting self-efficacy and Negative Mood: Evaluate the extent to which, among mothers of infants, variations in parenting self-efficacy beliefs are related to variations in negative mood.

Hypotheses 5a) Variations in parenting self-efficacy will be associated with variations in daily mood, such that, across moments in the day (Hypothesis 5b) and across days (Hypothesis 5c), parenting self-efficacy will be lower in relation to more negative mood.

Specific Aim Six

Relationship of parenting self-efficacy and Perceived Stress: Evaluate the extent to which, among mothers of infants, variations in parenting self-efficacy beliefs are related to variations in perceived stress.

Hypotheses 6a) Variations in parenting self-efficacy will be associated with variations in perceived stress, such that, across moments in the day (Hypothesis 6b) and across days (Hypothesis 6c), parenting self-efficacy will higher in relation to lower perceived stress and lower in relation to higher perceived stress.

Method

Recruitment

We recruited first time mothers of four to nine month old infants residing in the United States using the following approaches: word of mouth, flyers at approved or public locations such as pediatricians' offices, pre- and neo-natal classes, farmer's markets, media-based marketing campaigns, and by posting in online communities like local parenting blogs and Facebook groups. We also recruited participants through ResearchMatch, a national health volunteer registry of individuals who consented to be contacted by researchers about studies for which they may be eligible.

To determine the sample size needed in order to detect a small ($f^2 = 0.03$) to medium ($f^2 = 0.15$) effect, we performed a priori power analyses in G*Power (Version 3.1.9.4; Faul et al., 2007). We conducted power analyses to determine the sample size needed to detect both a small and medium effect because the few published EMA studies of parenting did not consistently report effect sizes. Results of our power analyses indicated we needed 55 participants to detect a medium effect and 250 participants to detect a small effect. We aimed to recruit around 250 participants based on these results as well as examination of sample sizes in similar published studies.

Determination of Eligibility

To determine eligibility, i.e. the presence of a four to nine month old child in the home and no older children, we screened potential participants through an online survey. We verified that potential participants lived within the United States through their cell phone number and carrier. Additional eligibility criteria were the mothers being 18 years of age or older and able to give consent, willingness to participate throughout the full seven days of the study, access to a computer and cell phone, and ability to speak and read the English language (evaluated through ability to provide written consent).

Participants

A total of 221 eligible mothers consented to participate and completed baseline measures. We excluded mothers (n = 66) who did not complete at least one daily survey. Our final sample consisted of n = 155 mothers (70% retention). Tables 1 and 2 display demographic characteristics and means and standard deviations of baseline variables, respectively, of the final sample and those we excluded. Excluded mothers were slightly, but statistically significantly younger, but did not differ from included mothers on any other demographic characteristic. On baseline measures, excluded mothers reported significantly higher symptoms of anxiety and significantly better sleep quality than mothers in our final sample. Mothers in our final sample were, on average, 31.75 years old, about 20% were not Caucasian, and most mothers were married, highly educated, and employed full time.

Procedures

The Emory University Institutional Review Board approved the research protocol. We collected and managed study data using REDCap (Harris et al., 2009) electronic data capture tools hosted at Emory University.

Consent

We included a link to the study website on all recruitment materials and we sent links directly to participants who contacted us or indicated their interest in participating through ResearchMatch. Upon logging into the study website, mothers first saw the informed consent form. Instructions guided them to read it and asked them to sign it digitally, indicating their understanding of the study and agreement to participate.

Protocol

We automatically sent participants who digitally signed the consent form or clicked on a public survey a link to the baseline questionnaires on RedCap (Harris et al., 2009). As part of completing the

baseline questionnaires, mothers provided their email address and cell phone number in order to receive text notifications for daily online questionnaires.

Mothers completed baseline questionnaires to provide demographic information as well as baseline measures of depressive symptoms, anxiety symptoms, stress, mood, social support, sleep quality and infant temperament to test Aim 1. Upon completion of baseline measures, we manually entered eligible mothers (i.e., those who indicated that they were a first-time mother of an infant aged 4 to 9 months and whose cell phone numbers indicated that they reside in the U.S.) in RedCap to receive automated text messages that included a link to a RedCap survey at scheduled times.

We sent mothers surveys by text four times a day over the course of seven days. We chose four surveys a day for seven days based on multiple recently published EMA studies that used a similar approach, and a systematic review of EMA studies of mood, in which the majority of included studies of depression used a measurement method of under a week, with many administering under 5 observations a day (aan het Rot et al., 2012). In addition, undue response burden negatively affects validity of measurement (Asselbergs et al., 2016a) and compliance has been found to drop significantly from week one to two of data collection (Broderick et al., 2003). Based on piloting, the total respondent burden was about 20 minutes for initial questionnaires and 12 minutes per day, for seven days, for a total of 104 minutes.

Measures

Demographic Measures

Mothers completed a demographic questionnaire created for this study that asked for information such as their age and race/ethnicity, number and ages of their children, income, marital status, and education.

Baseline Measures

Parenting Self-Efficacy. We measured baseline parenting self-efficacy with the Parenting Sense of Competence Scale (PSOC; Ohan et al., 2000). The PSOC is a 17 item self-report measure that assesses parental self-efficacy. Respondents rate items on a 6-point Likert scale, ranging from 1 (strongly disagree) to 6 (strongly agree), with no specified time frame. The potential range of scores is from 17 to 102, with higher scores indicating higher self-efficacy. The PSOC is widely-used and has demonstrated good internal consistency and validity (Ohan et al., 2000), and is among the most widely used measures of parenting self-efficacy (Wittkowski et al., 2017). In our sample, the PSOC had a Chronbach's alpha of 0.86.

Depressive and Anxiety Symptoms and Stress. We measured baseline levels of depressive and anxiety symptoms and stress using the Depression Anxiety and Stress Scale (DASS; Lovibond & Lovibond, 1995). The DASS is a widely-used, 42 item self-report measure that assesses symptoms of depression (e.g., dysphoria, hopelessness, anhedonia, etc.), symptoms of anxiety (e.g., autonomic arousal, worry, etc.), and stress (e.g., difficulty relaxing, nervous arousal, being easily upset, etc.). Items are scored on a four-point severity/frequency scale, ranging from 0 (did not apply to me at all) to 3 (applied to me very much, or most of the time) based on the extent to which participants have experienced each state over the past week. The DASS yields scores on depression, anxiety, and stress that potentially range from 0 to 42. Higher scores indicate higher symptom levels. The DASS has shown good reliability, validity, internal consistency and concurrent validity (Antony et al., 1998). In our sample, the depression scale had a Chronbach's alpha of 0.94, the anxiety scale had a Chronbach's alpha of 0.87, and the stress scale had a Chronbach's alpha of 0.93.

Social Support. We measured mothers' social support using the Multidimensional Scale of Perceived Social Support (MSPSS; Zimet et al., 1988). The MSPSS is a 12-item scale that assesses the subjective adequacy of one's social support, with no specified time frame. Participants rate their level of agreement with support-related statements (e.g., "I get the emotional help and support I need from my

family") on a 7-point Likert Scale, ranging from 1 (very strongly disagree) to 7 (very strongly agree). Scores range from 7 to 84, with higher overall scores indicate higher perceived support. The MSPSS has demonstrated good internal and test-retest reliability (Zimet et al., 1988). In our sample, the MSPSS had a Chronbach's alpha of 0.94.

Sleep Quality. We measured mothers' sleep quality using the Pittsburgh Sleep Quality Index (PSQI: Buysse et al., 1989), a 19 item self-report measure that assesses sleep quality and disturbances over the previous month. The PSQI generates seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. These component scores range from 0-3 and are summed to create a global scale. Scores range from 0 to 21, with higher global scores indicating lower sleep quality. The PSQI has shown good internal consistency and construct reliability (Carpenter & Andrykowski, 1998). In our sample, the PSQI had a Chronbach's alpha of .73.

Infant Temperament. We measured infants' temperament using the Infant Behavior Questionnaire-Revised, Very Short Form (IBQ- R- VSF; Putnam et al., 2014), a commonly used index of infant temperament in which caregivers describe infants' typical responses to home situations. The IBQ-R-VSF is a 37-item measure in which parents are asked to report the frequency with which infants have enacted the specific behaviors described in each item over the past two weeks. Parents rate their infant on a seven-point scale for each item, ranging from 1 (never) to 7 (always). The IBQ-R-VSF yields scores on three broad scales: surgency, negative affect, and effortful control. Items within each scale are averaged and potentially range from 1 to 7. Higher scores indicate higher prevalence of the domain's trait. These scales were developed to measure factors that have been derived from exploratory factor analyses of the instrument, and items within these scales were chosen based on their high correlations with their intended factor (Putnam et al., 2014). These factor scores have shown longitudinal stability, and convergent and predictive validity (Putnam et al., 2014). In our sample, the IBQ-R-VSF had a Chronbach's alpha of 0.70 on the surgency subscale, 0.83 on the negative affect scale, and a 0.70 on the effortful control subscale.

EMA Measures

Mothers completed the following measures four times per day. For each question, they were asked to answer it in relation to the time since the previous alert (even if they had failed to respond to the previous alert). We included data from subsequent surveys, even if mothers failed to respond to the previous alert for two main reasons. First, all surveys contain important data and contribute to our aims. Second, mothers were sent daily surveys at the same times each day of the study and received text alerts at each timepoint that contained survey links. Therefore, 'since the last alert' was still a meaningful reference point, regardless of whether the previous survey was completed.

Parenting Self-Efficacy. Following the approach used by other EMA studies of parenting (Li & Lansford, 2018), we selected items from our baseline measure of PSE for our EMA surveys. We measured momentary parenting self-efficacy using three items from the Parenting Sense of Competence Scale (PSOC; Ohan et al., 2000). We selected the following three items from the PSOC based on their having been highly correlated to the full scale in a normative sample of parents (Gilmore & Cuskelly, 2009): "Since the last alert, I have made a fine model for a new mother to follow in order to learn what she would need to know in order to be a good parent," "in the past hour, I met my own personal expectations for expertise in caring for my child," and "in the past hour, if anyone could have found an answer to what was troubling my child, it was me." As with the full scale, participants rated their agreement with items on a 6-point Likert scale, ranging from 1 (strongly disagree) to 6 (strongly agree). Scores from responses to these three items were summed to create a PSE score, potentially ranging from 3 to 18, with higher scores indicating higher levels of parenting self-efficacy. In our sample, this daily PSE measure had a mean Chronbach's alpha of 0.88.

Depressive and Anxiety Symptoms. We measured momentary depressive and anxiety symptoms using the Patient Health Questionnaire-Four (PHQ-4; Kroenke et al., 2009), a well-validated, four-item screener with two items for depression and two items for anxiety that has previously been used in EMA studies (Mattos et al., 2019; Smiley et al., 2017). The PHQ-4 measures the frequency of

depressed mood and anhedonia (i.e., depression) and feelings of nervousness and worry (i.e., anxiety). Respondents rate items on a four-point Likert scale ranging from 0 (not at all) to 3 (nearly all the time) and yields a total score; potential scores range from 0 to 12 with higher scores indicating higher symptoms levels. The PHQ-4 has been shown to exhibit strong internal reliability, construct validity, and factorial validity, and scores on the PHQ-4 are strongly associated with functional impairment (Kroenke et al., 2009). In our sample, the PHQ-4 had a Chronbach's alpha of 0.93.

Positive and Negative Mood. We assessed momentary maternal mood through a combination of 11 positive and negative mood items used in EMA studies by Peeters et al. (2006), plus the five positive affect items from the Positive and Negative Affect Schedule- Short Form (PANAS; Watson et al., 1988). Using these 16 items, we created a negative mood scale (n = 5 items) and positive mood scale (n = 11 items). We chose these mood items for several reasons. First, along with other researchers who have assessed mood using EMA methodology (Barge-Schaapveld & Nicolson, 2002; Myin-Germeys et al., 2001; Myin-Germeys et al., 2003), we used the five negative mood items from Peeters et al. (2006) because they are thought to capture more clinically relevant aspects of daily mood that may be associated with symptoms of depression and anxiety, including pleasant-unpleasant and activation- arousal dimensions, than the PANAS negative affect scale (Peeters et al., 2006). Further, these negative mood items reflect affective states such as feeling tense or easily distracted that may be more relevant to the experience of parenting than the negative mood items in the NA scale of the PANAS (Watson et al., 1988).

In terms of positive mood, the positive mood items used by Peeters and colleagues (Peeters et al., 2006) reflect additional dimensions of positive affect that may be especially relevant to mothers' experience of parenting and their PSE, such as happiness, satisfaction, and self-assurance. As such, we used these mood items in addition to the five positive mood items of the PANAS (Watson et al., 1988).

The Peeters et al. (2006) items and the PANAS are rated on a 5-point Likert Scale, ranging from 1 (very slightly or not at all) to 5 (extremely), indicating the extent to which the participant is

experiencing the emotion. Items were averaged within the positive and negative mood scales. Thus, totals ranged potentially from 1 to 5, with higher scores indicating more positive or more negative mood. In our sample, our mood measure had a Chronbach's alpha of 0.83 for negative mood and 0.95 for positive mood.

Maternal Stress. We measured momentary perceived maternal stress using the Perceived Stress Scale-Short Form (PSS-4; Cohen, 1988). The PSS-4 is a four-item measure of perceived stress adapted from the Perceived Stress Scale (Cohen et al., 1983) for use in research designs that require brevity, and has been previously used in EMA studies (King et al., 2019; Massabni, 2019; Pryss et al., 2019). The PSS-4 assesses the extent to which participants view their lives as unpredictable, uncontrollable, and overloaded, with higher scores indicating more stress. Items are rated on a four-point Likert scale, from 0 (never) to 4 (very often); total scores range from 0 to 16. Higher scores indicate higher perceived stress. The PSS-4 has demonstrated internal consistency (Warttig et al., 2013) and concurrent and convergent validity (Karam et al., 2012; Vallejo et al., 2018). In our sample, the PSS-4 had a Chronbach's alpha of 0.70.

Analytical Approach

Preliminary Analyses

We conducted preliminary analyses using SPSS (Version 26). We inspected frequency distributions and descriptive statistics in order to summarize demographic characteristics. We also examined potential infant sex differences on baseline measures. We also examined response rates of EMA surveys and associations among response rates and baseline variables.

Aim 1

Analyses for Aim 1 sought to replicate previous findings of a significant, negative association between parenting self-efficacy and symptoms of depression at baseline and to examine associations among PSE and infant temperament, and mothers' symptoms of anxiety, stress, sleep quality, and

perceived social support. We generated Pearson correlations to test the first hypothesis, that PSE would be significantly, negatively associated with symptoms of depression and anxiety (DASS depression scale and DASS anxiety scale, respectively), and to test the relationships among PSE and a set of context variables: maternal stress (DASS stress scale), mothers' sleep quality (PSQI), and mothers' social support (MSPSS) and infant temperament (IBQ-R-VSF).

Aims 2-6

To test hypotheses from Aims 2 through 6, we conducted multilevel modeling using Hierarchical Linear Modeling 8 (HLM-8; student version) software to explore the association between parenting self-efficacy and a set of time-varying predictor variables. HLM-8 allows for the use of nested models, which enabled us to examine changes in PSE within and between participants across multiple time points rather than collapsing measures of variables of interest. We computed correlations among hypothesized predictor variables to assess multicollinearity; evidence of correlations among predictor variables provided justification for running separate models for each predictor.

We examined demographic variables as potential covariates prior to running our primary HLM analyses by running a series of models with demographic characteristics entered as a predictor of our outcome variable, PSE. We included demographic characteristics that exerted a significant influence on PSE as covariates in all subsequent models.

To calculate effect sizes and conduct post-hoc power analyses, we took the following steps. First, we calculated the R^2 values for the between- and within-person variability of each model using methods explained in a manual for HLM-Version 7 (HLM-7 Manual; Smeets). From these R^2 values, we calculated effect sizes (Cohen's $f^2 = R^2 / (1- R^2)$; Cohen, 1988) which we then used to calculate post-hoc power for each analysis in G*Power (Version 3.1.9.4; Faul et al., 2007).

Aim 2. To test hypotheses regarding the between and within-person variability of PSE among mothers of infants, we first ran an unconditional growth model to quantify the rate of change in PSE. Next, we included two different time variables, time of day and day of the study. Following the approach

commonly used in analyses of intensive longitudinal data (Inauen et al., 2016), we used a coding scheme that creates a meaningful zero point for time of day and day. Specifically, we coded time of day as: 0 = 7:30- 8:30 a.m., 1 = 4:30- 5:30 p.m., 2 = 6:30-7:30 p.m., and 3 = 9:30-10:30 p.m. We coded day of the study as a factor as: 0 = day one, 1 = day two, 2 = day three, 3 = day four, 4 = day five, 5 = day six, and 6 = day seven. To test the hypotheses that there would be between and within person variability in PSE over the course of the day and across days of the study, we ran two unconditional growth models with time of day and day entered as level 1 predictors, respectively.

Aim 3. To test the hypothesis that variations in PSE will be associated with variations in symptoms of depression and anxiety, we conducted a series of hierarchical linear models. To examine the within-person variability, we centered symptoms of depression/anxiety at the person mean, resulting in intrapersonal fluctuations around the person-specific mean across the study period. We entered symptoms of depression and anxiety (person-mean centered) and time of day (time-varying) as Level 1 predictors of PSE. Next, we entered symptoms of depression and anxiety (person- mean centered) and day of the study (time-varying) as Level 1 predictors of PSE.

Aims 4 and 5. To test the hypothesis that variations in PSE will be associated with variations in maternal mood, we conducted two separate series of hierarchical linear models. To examine the within-person variability, we centered both positive mood and negative mood at the person mean for each scale, resulting in intrapersonal fluctuations around the person-specific means across the study period. Following guidelines put forth by Bolger and Laurenceau (2013), we also grand-mean centered positive mood and negative mood in order to establish an interpretable zero point. We entered positive mood (grand and person-mean centered) and time of day (time-varying) as Level 1 predictors of PSE. Next, we entered positive mood (grand and person-mean centered) and day (time-varying) as Level 1 predictors of PSE. Next, we entered negative mood (grand and person-mean centered) and time of day (time-varying) as Level 1 predictors of PSE. Next, we entered negative mood (grand and person-mean centered) and day (time-varying) as Level 1 predictors of PSE.

Aim 6. To test the hypothesis that variations in PSE will be associated with variations in levels of perceived stress, we conducted a series of hierarchical linear models. To examine the within-person variability, we centered perceived stress at the person mean, resulting in intrapersonal fluctuations around the person-specific mean across the study period. We entered perceived stress (person-mean centered) and time of day (time-varying) as Level 1 predictors of PSE. Next, we entered symptoms of perceived stress (person- mean centered) and day of the study (time-varying) as Level 1 predictors of PSE.

Results

Preliminary Analyses

Table 2 shows means and standard deviations of baseline variables. We found no significant differences on baseline measures by infant sex. Mothers completed an average of 16.64 (SD = 8.79) surveys, or 59.4% of all possible surveys, with a range from 3.6% to 100% completion. Response rate was significantly correlated with only one of the baseline variables; lower response rate was associated with higher baseline maternal symptoms of anxiety (see last line of Table 3). Table 3 also shows correlations among all of the baseline variables; we return to Table 3 for the description of findings relevant to Aim 1.

See Table 4 for means, standard deviations and number of surveys completed for all EMA variables by time point. Table 5 displays correlations among EMA variables across all survey timepoints. All hypothesized predictor variables (symptoms of depression and anxiety, positive mood, and negative mood) were significantly intercorrelated. As such, we ran separate models for each predictor. Preliminary analyses regarding potential covariates revealed that maternal education level exerted a significant influence on PSE and was therefore included as a covariate in all HLM analyses. See Table 6 for a complete list of variables we examined as potential covariates.

Aim 1: Association among PSE and Maternal and Infant Characteristics

Findings regarding Hypotheses 1, that PSE would be associated with symptoms a set of maternal

and infant characteristics, were mixed (see column 1 in Table 3). In partial support of Hypothesis 1A, PSE (labeled as PSOC in Table 3) was significantly, negatively associated with the DASS depression scale, r = -0.24, p =.003, but was not significantly associated with the DASS anxiety scale. In partial support of Hypothesis 1B, that baseline PSE would be associated with a set of maternal and infant characteristics, baseline PSE was significantly, negatively associated with the DASS stress scale, r = -0.27, p = 0.001, but was not significantly associated with perceived social support or sleep quality. Further, PSE was significantly associated with two of the three domains of infant temperament, in the predicted directions: positively associated with effortful control and negatively associated with negative affect, r = 0.23, p = 0.004, and r = -0.25, p = 0.002, respectively, but not significantly associated with the surgency domain of infant temperament

Aim 2: Dynamics of PSE over the course of the day and from day to day.

Next, we describe results from the HLM analyses of the EMA data to test Hypothesis 2, that PSE would be variable over the course of the day and over the course of the study. We ran an intercept-only model which revealed that the mean level of PSE across all time points was 15.24 (SD = 1.07). The intraclass correlation for PSE was 0.55, suggesting that 55% of the variation in PSE was attributable to the person and 45% was attributable to fluctuations within-persons. Next, we used HLM to assess the effect of time on PSE (see Table 7). Our hypothesis was supported, as PSE increased significantly over the course of the day, $\beta = 0.12$, $p < 0.001$ and over the days of the study, $\beta = 0.08$, $p = 0.03$. There was a significant amount of within-person variability, $\sigma^2 = 3.52$, χ^2 (df = 146) = 4007.11, $p < 0.001$, $f^2 = 0.03$, $(1 - \beta) = 0.58$, in the relationship between PSE and time of day. There was also a significant amount of between person variability, $\sigma^2 = 5.54$, χ^2 (df = 129) = 1423.43.00, $p < 0.001$, $f^2 = 0.13$, $(1 - \beta) = 1.00$, and within person variability, $\sigma^2 = 3.17$, χ^2 (df = 130) = 387.86, $p = 0.001$, $f^2 = 0.01$, $(1 - \beta) = 0.23$, in the relationship between PSE and day of the study.

Aim 3: Dynamics of PSE and Mothers' Symptoms of Depression and Anxiety

To test Hypothesis 3a, that variability in PSE would be associated with variability in symptoms of depression and anxiety, we entered maternal symptoms of depression and anxiety (person centered) as a Level 1 predictor in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (maternal depression/anxiety)} + \text{error}$$

Results supported Hypothesis 3a in that maternal depression and anxiety exerted a significant influence on PSE across all time points, $\beta = -0.32$, $p < 0.001$ (see Table 7). There was significant between-person variability, $\sigma^2 = 5.39$, χ^2 ($df = 130$) = 4065.11, $p < 0.001$, $f^2 = 0.13$, $(1 - \beta) = 0.99$, and within-person variability, $\sigma^2 = 3.22$, χ^2 ($df = 131$) = 260.37, $p < 0.001$, $f^2 = 0.04$, $(1 - \beta) = 0.71$, in the relationship between PSE and maternal depression and anxiety.

Next, to test Hypothesis 3b, that variability in PSE would be associated with variability in symptoms of anxiety and depression over the course of the day, we entered maternal symptoms of depression and anxiety (person centered) and time of day (uncentered) as Level 1 predictors of parenting self-efficacy in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (maternal depression/anxiety)} + \beta_2 \text{ (time of day)} + \text{error}$$

The results supported Hypothesis 3b in that both maternal depression/anxiety and time of day significantly predicted PSE, such that PSE increased slightly over the course of the day, $\beta = 0.08$, $p = 0.02$, and decreased in relation to increases in symptoms of depression/anxiety, $\beta = -0.32$, $p < 0.001$ (see Table 7). There was a significant amount of between person variability, $\sigma^2 = 5.39$, χ^2 ($df = 130$) = 4075.00, $p < 0.001$, $f^2 = 0.13$, $(1 - \beta) = 0.99$, and within person variability, $\sigma^2 = 3.22$, χ^2 ($df = 131$) = 261.71, $p < 0.001$, $f^2 = 0.04$, $(1 - \beta) = 0.70$.

Next, to test Hypothesis 3c, that variability in PSE would be associated with variability in symptoms of anxiety and depression over the days of the study, we entered maternal symptoms of

depression and anxiety (person centered) and day (uncentered) as Level 1 predictors of parenting self-efficacy in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (maternal depression/anxiety)} + \beta_2 \text{ (day)} + \text{error}$$

Results from testing this model failed to support Hypothesis 3c in that, when considering symptoms of depression and anxiety and day in the same model, maternal depression/anxiety significantly predicted PSE, such that PSE decreased in relation to increases in symptoms of depression/anxiety, $\beta = -0.33$, $p < 0.001$, but day of the study did not (see Table 7). However, there was a significant amount of between person variability, $\sigma^2 = 5.41$, χ^2 ($df = 119$) = 1276.27, $p < 0.001$, $f^2 = 0.26$, $(1 - \beta) = 1.00$, and within person variability, $\sigma^2 = 2.89$, χ^2 ($df = 120$) = 240.28, $p < 0.001$, $f^2 = 0.03$, $(1 - \beta) = 0.58$, in the relationship between PSE and symptoms of depression/anxiety across the days of the study, which provides partial support for Hypothesis 3b.

Aim 4: Dynamics of PSE and Mothers' Positive Mood

To test Hypothesis 4a, that variability in PSE would be associated with variability in positive mood, we entered maternal positive mood (person and grand mean centered) as a Level 1 predictor in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (Maternal positive mood)} + \text{error}$$

Results of testing this model revealed support for Hypothesis 4 in that maternal positive mood exerted a significant influence on PSE across all time points, $\beta = 0.88$, $p < 0.001$ (see Table 7). There was significant between person variability, $\sigma^2 = 5.46$, χ^2 ($df = 140$) = 4418.32, $p < 0.001$, $f^2 = 0.17$, $(1 - \beta) = 1.00$, and within-person variability, $\sigma^2 = 3.11$, χ^2 ($df = 141$) = 324.40, $p < 0.001$, $f^2 = 0.02$, $(1 - \beta) = 0.42$, in the relationship between positive mood and PSE.

Next, to test Hypotheses 4b, that variability in PSE would be associated with variability in positive mood over the course of the day, we entered maternal positive mood (person and grand mean

centered) and time of day (uncentered) as Level 1 predictors of parenting self-efficacy in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (Maternal positive mood)} + \beta_2 \text{ (time of day)} + \text{error}$$

We found support for Hypotheses 4b in that both maternal positive mood and time of day significantly predicted PSE, such that PSE increased slightly over the course of the day, $\beta = 0.11$, $p = 0.02$, and increased in relation to increases in positive mood, $\beta = 0.90$, $p < 0.001$ (see Table 7). There was significant between person variability, $\sigma^2 = 5.45$, χ^2 ($df = 140$) = 4436.77, $p < 0.001$, $f^2 = 0.17$, $(1 - \beta) = 1.00$, and within-person variability, $\sigma^2 = 3.10$, χ^2 ($df = 141$) = 322.63, $p < 0.001$, $f^2 = 0.03$, $(1 - \beta) = 0.58$, in the relationship between positive mood and PSE over the course of the day.

Next, to test Hypotheses 4c, that variability in PSE would be associated with variability in positive mood across the days of the study, we entered maternal positive mood (person centered) and day (uncentered) as Level 1 predictors of parenting self-efficacy in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (Maternal positive mood)} + \beta_2 \text{ (day)} + \text{error}$$

Results of testing this model revealed support for Hypothesis 4c in that both maternal positive mood and day of the study significantly predicted PSE, such that PSE increased slightly over the course of the day, $\beta = 0.06$, $p = 0.03$, and increased in relation to increases in positive mood, $\beta = 0.90$, $p < 0.001$ (see Table 7). There was significant between person variability, $\sigma^2 = 5.39$, χ^2 ($df = 129$) = 1365.67, $p < 0.001$, $f^2 = 0.28$, $(1 - \beta) = 1.00$, and within-person variability, $\sigma^2 = 2.83$, χ^2 ($df = 141$) = 280.85, $p < 0.001$, $f^2 = 0.04$, $(1 - \beta) = 0.70$, in the relationship between positive mood and PSE across the days of the study.

Aim 5: Dynamics of PSE and Mothers' Negative Mood

To test Hypothesis 5a, that variability in PSE would be associated with variability in negative mood, we entered maternal negative mood (person and grand mean centered) as a Level 1 predictor in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (Maternal negative mood)} + \text{error}$$

Results of testing this model revealed support for Hypothesis 5a in that maternal negative mood exerted a significant influence on PSE across all time points, $\beta = -0.99$, $p < 0.001$ (see Table 7). There was significant between person variability, $\sigma^2 = 5.50$, χ^2 ($df = 140$) = 4580.18, $p < 0.001$, $f^2 = 0.19$, $(1 - \beta) = 1.00$, and within-person variability, $\sigma^2 = 3.06$, χ^2 ($df = 141$) = 312.50, $p < 0.001$, $f^2 = 0.02$, $(1 - \beta) = 0.42$, in the relationship between negative mood and PSE.

Next, to test Hypothesis 5b, that variability in PSE would be associated with variability in negative mood over the course of the day, we entered maternal negative mood (person and grand mean centered) and time of day (uncentered) as Level 1 predictors of parenting self-efficacy in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (Maternal negative mood)} + \beta_2 \text{ (time of day)} + \text{error}$$

Results of testing this model did not reveal support for Hypothesis 5b; while maternal negative mood significantly predicted PSE, such that PSE decreased in relation to increases in negative mood, $\beta = -0.97$, $p = < 0.001$, time of day did not (see Table 7). However, there was significant between person variability, $\sigma^2 = 5.50$, χ^2 ($df = 140$) = 4582.40, $p < 0.001$, $f^2 = 0.19$, $(1 - \beta) = 1.00$, and within-person variability, $\sigma^2 = 3.06$, χ^2 ($df = 141$) = 312.02, $p < 0.001$, $f^2 = 0.02$, $(1 - \beta) = 0.42$, in the relationship between negative mood and PSE over the course of the day which provides partial support for Hypothesis 5b.

Next, to test Hypothesis 5c, that variability in PSE would be associated with variability in negative mood over the course of the study, we entered maternal negative mood (person and grand mean centered) and day (uncentered) as Level 1 predictors of parenting self-efficacy in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (Maternal negative mood)} + \beta_2 \text{ (day)} + \text{error}$$

Results of testing this model did not reveal support for Hypothesis 5c; while maternal negative mood

significantly predicted PSE, such that PSE decreased in relation to increases in negative mood, $\beta = -1.02$, $p < 0.001$, day of the study did not (see Table 7). However, there was significant between person variability, $\sigma^2 = 5.45$, χ^2 ($df = 127$) = 1482.90, $p < 0.001$, $f^2 = 0.32$, $(1 - \beta) = 1.00$, and within-person variability, $\sigma^2 = 2.75$, χ^2 ($df = 128$) = 282.39, $p < 0.001$, $f^2 = 0.03$, $(1 - \beta) = 0.58$, in the relationship between negative mood and PSE across the days of the study, which provides partial support for Hypothesis 5c.

Aim 6: Dynamics of PSE and Mothers' Perceived Stress

To test hypotheses 6a, that variability in PSE would be associated with variability in perceived stress, we entered maternal perceived stress (person centered) as a Level 1 predictor in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta 1 \text{ (maternal perceived stress)} + \text{error}$$

Results of testing this model revealed support for Hypothesis 6a, such that maternal perceived stress exerted a significant influence on PSE across all time points, $\beta = -0.24$, $p < 0.001$ (see Table 7). There was a significant amount of between person variability, $\sigma^2 = 5.45$, χ^2 ($df = 135$) = 4026.95, $p < 0.001$, $f^2 = 0.16$, $(1 - \beta) = 1.00$, and within person variability, $\sigma^2 = 3.14$, χ^2 ($df = 136$) = 219.45, $p < 0.001$ $f^2 = 0.03$, $(1 - \beta) = 0.58$, in the relationship between perceived stress and PSE.

Next, to test Hypothesis 6b, that variability in PSE would be associated with variability in perceived stress over the course of the day, we entered maternal perceived stress (person centered) and time of day (uncentered) as Level 1 predictors of parenting self-efficacy in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (maternal perceived stress)} + \beta_2 \text{ (time of day)} + \text{error}$$

Results of testing this model revealed support for Hypothesis 6b, in that both maternal perceived stress and time of day significantly predicted PSE; PSE increased slightly over the course of the day, $\beta = 0.09$, $p = 0.02$, and decreased in relation to increases in perceived stress, $\beta = -0.23$, $p < 0.001$ (see Table 7). There

was a significant amount of between person variability, $\sigma^2 = 5.44$, χ^2 ($df = 135$) = 4119.92, $p < 0.001$, $f^2 = 0.16$, $(1 - \beta) = 1.00$, and within person variability, $\sigma^2 = 3.13$, χ^2 ($df = 131$) = 218.53, $p < 0.001$, $f^2 = 0.03$, $(1 - \beta) = 0.58$, which provides partial support for Hypothesis 6b.

Next, to test the Hypothesis 6c, that variability in PSE would be associated with variability in perceived stress over the course of the study, we entered maternal perceived stress (person centered) and day (uncentered) Level 1 predictors of parenting self-efficacy in the following model:

$$\text{Maternal PSE} = \beta_0 + \beta_1 \text{ (maternal perceived stress)} + \beta_2 \text{ (day)} + \text{error}$$

Results of testing this model did not reveal support for Hypothesis 6c; while maternal perceived stress significantly predicted PSE, such that PSE decreased in relation to increases in perceived stress, $\beta = -0.22$, $p < 0.001$, day of the study did not (see Table 7). However, there was a significant amount of between person variability, $\sigma^2 = 5.41$, χ^2 ($df = 130$) = 1283.15, $p < 0.001$, $f^2 = 0.16$, $(1 - \beta) = 1.00$, and within person variability, $\sigma^2 = 2.86$, χ^2 ($df = 131$) = 189.41, $p < 0.001$, $f^2 = 0.03$, $(1 - \beta) = 0.58$, which provides partial support for Hypothesis 6c.

Discussion

The current study contributes to the literature on PSE in several ways. First, we built on and extended previous findings by examining cross-sectional associations among PSE and a host of theory- and empirically-justified potential maternal and infant characteristics in first time mothers of infants. Second, we used a novel methodological approach (daily mobile-based questionnaires) to empirically assess PSE as a dynamic construct. Third, with that same approach, we examined how fluctuations in symptoms of depression and anxiety, mood, and perceived stress were associated with PSE beliefs in the moment over the course of the day and across the days of the study. By investigating the dynamics of PSE and how maternal characteristics were associated with PSE over time, we addressed the following significant gaps in the literature: (1) reliance on cross-sectional associations, (2) common use of a single measurement of PSE, (3) lack of study of maternal characteristics that have been hypothesized to

dynamically affect PSE. This novel approach allowed us to examine heretofore unanswered questions about the relationships between maternal depressive and anxiety symptoms, maternal positive and negative mood, perceived stress, and PSE beliefs in the moment and in ecologically valid settings.

Our first *aim* was to investigate cross-sectional associations among PSE and a set of maternal and infant characteristics. First, we replicated previous findings of significant, negative associations between PSE and symptoms of depression and maternal stress in our sample of first-time mothers of infants aged four to nine months. Higher levels of depressive symptoms and higher stress levels were associated with lower PSE, with medium effect sizes. Second, we extended previous findings on PSE and infant temperament by examining the associations between PSE and three dimensions of infant temperament: negative affect, effortful control, and surgency. We found significant associations between PSE and both negative affect and effortful control, such that PSE was negatively associated with infant negative affect and positively associated with effortful control. These findings provide support for theory that aspects of infant temperament beyond negative affect are associated with PSE beliefs. However, we did not find a significant association between baseline PSE and the surgency dimension of infant temperament. We expected this association given theory and previous findings that joy, an index of surgency, was associated with warm parenting among mothers of infants (Kochanska et al., 2004). Nonetheless, our finding is consistent with Chang and Li (2017), who found that surgency, in contrast to the other two temperament factors, did not predict mothers' emotion-focused supportive reactions.

Third, our study took the further step of testing cross-sectional associations between PSE and maternal symptoms of anxiety, which has been largely neglected in the literature. However, contrary to our expectation, we did not find a significant association between PSE and maternal anxiety in our sample. The majority of studies that have previously examined PSE in relation to anxiety have done so in the context of comorbid depression (Kohlhoff & Barnett, 2013; Porter & Hsu, 2003) and stress (Leahy-Warren et al., 2012). Our findings suggest that mothers' anxiety alone may not contribute significantly to PSE. Future studies might consider how anxiety either in addition to or in interaction with depression and

stress may be associated with lower PSE. In our sample, depression and anxiety were highly correlated, and PSE was significantly, negatively associated with the total score on the Depression, Anxiety, and Stress Scale (DASS; Lovibond & Lovibond, 1995). Further, one study that examined maternal anxiety and PSE found a significant association at one month postpartum, but not at three months postpartum (Porter & Hsu, 2003). Future research is needed to determine potential age-specific associations between PSE and anxiety across infancy.

Fourth, contrary to Hypothesis1B, we did not find a significant association between PSE and social support or maternal sleep quality. In terms of social support, published findings of a significant association with PSE in mothers of infants have largely been found in mothers of infants younger than three months (Cutrona & Troutman, 1986; Gao et al., 2014; Leahy-Warren et al., 2012). Although we expected that these associations would hold true through later infancy, it may be that by the time infants are older and mothers have adjusted to their parenting role and have established a routine, social support may play less of a role in the determination of PSE than it has been found to have earlier in the postnatal period. In keeping with this idea, one study found that while social support declined significantly from six weeks to three months postpartum, PSE increased significantly during this time period (Gao et al., 2014) among first time mothers.

In terms of maternal sleep, whereas previous studies have largely focused on fatigue, our sleep measure assessed seven broad components of maternal sleep, taking a unique approach in testing relations between sleep and PSE. We expected an association between PSE and overall sleep quality based on findings that mothers of infants report considerable sleep disturbances (Dennis & Ross, 2005) and that a range of qualities of maternal sleep have been found to be associated with parenting perceptions (Tikotzky, 2016; Tikotzky et al., 2012). Nonetheless, we failed to support our predicted association. It may be that while aspects of sleep quality are associated with some aspects of parenting beliefs (i.e., perceptions of attachment), these do not extend to PSE specifically.

Our second *aim* addressed the fundamental theoretical assumption that PSE is a dynamic rather than stable construct. Theory of self-efficacy posits that it is a dynamic construct, yet the majority of studies that have examined PSE have relied on a single measure at a single time point. Therefore, the dynamics of PSE, or how much and in what ways it might change over time has been relatively neglected in the literature. The current study addressed this critical gap by examining PSE longitudinally using a novel methodological approach, ecological momentary assessment (EMA). This approach allowed us to address heretofore unanswered questions about PSE such as the extent to which PSE beliefs change over the day and week and how variations in PSE are related to fluctuations in maternal symptoms of depression and anxiety, mood, and perceived stress. EMA improves on researchers' typical approach of measuring PSE at only one or two time points, providing the opportunity to address the gap in our understanding of the extent to which PSE may change over time, both throughout the day and over the course of a week. EMA data collected throughout the day provides a representative and unbiased estimate of subjects' typical state (Shiffman, 2013), and thus, corrects for the limitations of previous studies' use of a single measurement of PSE to measure PSE over the previous weeks or months. Finally, use of EMA allowed us to examine within-person variability in PSE over time which augments our findings on the overall variability of PSE across all participants.

In support of *aim two*, we found evidence of significant variability in PSE. In our sample, PSE increased both over the course of the day and over the days of the study. Findings that PSE increased over the course of the day and week are in line with previous findings of an increase in PSE over time (Gao et al., 2014). This study was the first of its kind to assess PSE using intensive longitudinal methods, allowing to us to assess PSE dynamically and in the moment. The present findings provide empirical evidence for theory of the dynamics of self-efficacy beliefs among mothers and as such, provides directions for future research. Specifically, these findings suggest that a single measure of PSE is insufficient and that future studies of PSE should employ multiple measures of PSE. Further, findings of

significant variability suggest that parenting beliefs may be modifiable and are therefore a promising target of intervention.

In addition to questions related to overall variability of PSE, this study addressed questions related to potential maternal factors that were hypothesized to contribute to its variability. In support of *aim three*, we found that variability in PSE was significantly associated with variability in symptoms of depression and anxiety, considered together. Intrapersonal fluctuations in symptoms of depression and anxiety were associated with changes in PSE, such that mothers' reported increases in their depression and anxiety predicted their lower PSE. These findings provide support for theory of self-efficacy that changes in affective states are dynamically associated with self-efficacy beliefs. Our findings also add to the body of evidence that individuals experience daily fluctuations in depressive and anxiety symptoms (Hankin et al., 2005; Walz et al., 2014) and that such fluctuations are associated with self-efficacy beliefs. Evidence of fluctuations in symptoms of depression and anxiety and PSE highlight the limitations of previous' studies' sole reliance on cross- sectional associations between depression and parenting in that a single measure of each may not fully capture this association as it may differ across time. Use of EMA methodology allows for a more fine-grained understanding of these relationships and may be particularly well suited to studies measuring symptoms of depression and anxiety and PSE.

Similarly, in support of *aim four*, variability in PSE was associated with variability in positive mood, such that PSE was higher in relation to higher levels of positive mood over the course of the day and across the days of the study. We also found support for *aim five*, in that variability in PSE was also associated with variability in negative mood across all timepoints. However, when negative mood and time, either time of day or day of the study, were included in the same model, time did not exert a significant influence on PSE.

Across all models, we found significant within-person variability in the relationships among PSE and depression/anxiety and positive and negative mood. This suggests that individuals' PSE beliefs are variable and change dynamically in relation to intrapersonal fluctuations in mood. This provides

additional empirical support for theory that affective states beyond symptoms of depression and anxiety are dynamically associated with self-efficacy beliefs. Until now, mood has been almost entirely neglected as a correlate of PSE in the literature, a gap this study addressed. Further, findings that mood exerted a larger influence than symptoms of depression and anxiety affirm the importance of examining mood independently, beyond as a symptom of depression. Significant associations between mood and PSE, along with findings that of all the predictor variables we examined, negative mood exerted the largest influence, suggest the mothers with high levels of negative mood may be at particular risk based on their low PSE yet this population has been largely neglected in the literature.

Finally, in support of *aim six*, we found support for our hypothesis that variability in PSE was significantly associated with variability in perceived stress over the course of the day. In our sample, higher levels of perceived stress in the moment was associated with lower PSE. This finding provides support for theory of self-efficacy that perceptions of stress, and one's perceived ability to cope with that stress, influence perceptions of self-efficacy. As with symptoms of depression and anxiety, evidence of fluctuations in perceived stress and PSE suggest that this relationship may not be fully captured through concurrent cross-sectional associations between stress and parenting beliefs. Therefore, cross-sectional findings should be interpreted in the context that associations at a single time point do not fully capture this association. Future studies of perceived stress and PSE should therefore assess this relationship dynamically. In addition, a potential future direction is to consider whether perceived stress adds unique information to the prediction of variation is PSE, given findings that perceived stress is considered as a third component of overall psychological distress, along with depression and anxiety (Miller et al., 2006).

Limitations

These findings should be interpreted in the context of several limitations that provide direction for future studies. First, despite our broad, national recruitment efforts, the sample consisted of highly-educated and high-income mothers, with 53.4% of mothers having competed at least a graduate of professional degree and 40% of mothers reporting a family income of $125,000 and above. An important

next step would be to test these hypotheses in less resourced samples. Our findings may not generalize to mothers with less education or lower incomes, given that PSE has been found to be positively associated with higher levels of education and higher family incomes (Coleman & Karraker, 2000).

Second, we only studied mothers' PSE beliefs, and not fathers' PSE beliefs. Future studies are necessary to determine whether our findings generalize to fathers or other caregivers. One study found that fathers had lower self-efficacy beliefs related to infant care than did mothers (Hudson et al., 2001). Future research should examine what factors are associated with levels of PSE in fathers of infants and how they may be different from or similar to factors associated with PSE in mothers, including within families.

Third, on average, mothers in our study completed around 60% of daily surveys. Comparing this to published EMA studies, a recent review of EMA studies of adults with depressive symptoms reported compliance rates ranging from 65% to 99.5% (Kim et al., 2020) and a study of compliance patterns of respondents in an EMA study of mood found a mean compliance rate of 75% (Courvoisier et al., 2012) among adults. However, there have been relatively few EMA studies of parenting, and even fewer among parents of infants. As such, there are few points of direct comparison in the literature. An EMA study of mothers of children aged 8-12 years old reported a 78.9% response rate, while studies of parents of kindergarteners (Li & Lansford, 2018) and of five to seven year olds (Berge et al., 2017) did not report compliance rates. However, one study of infants discontinued the EMA portion of the study due to reports from participants who found it too burdensome to complete (Adams et al., 2019). Given the challenges and high daily demands of parenting infants, it is reasonable to expect a lower compliance rate relative to other studies of adults. Future research is needed to establish norms and standards for acceptable response rates among parents generally and in mothers of infants specifically.

Fourth, our sample size raises some concerns. On the one hand, we had a relatively small sample size (n = 155) compared to other published EMA studies of parenting, such as Dunton et al. (2019) who reported a n of 199 and Li and Lansford (2018) who reported an n of 184. On the other hand, one

published EMA of parenting had a comparable sample size to ours (n = 150; Berge et al., 2017) and published EMA studies of similar affective constructs, such as mood, report findings in comparable or smaller samples than ours, with *n*'s of 33, 121, 79, and 27 respectively (Asselbergs et al., 2016b; Connolly & Alloy, 2017; Silk et al., 2011; Wegner et al., 2002). Despite our relatively small sample size, and not achieving our intended sample size, results of our post-hoc power analyses revealed that we had sufficient power ($1 - \beta \geq 0.99$) to detect between-person effects in associations among PSE and symptoms of depression and anxiety, mood, and perceived stress across timepoints. However, we were underpowered ($1 - \beta < 0.80$) to detect within-person variability in these associations. This may be because we included mothers who only completed one EMA survey, which may have decreased our power to detect within-person effects over time. Future studies are needed to replicate our findings in samples with higher compliance rates, which may afford more power to detect such effects.

Fifth, the EMA portion of our study focused only maternal affective characteristics that were theorized to affect PSE. As such, we did not examine dynamic associations between maternal social support or sleep quality or any characteristics or behaviors of the infants and PSE. Although we did not find a significant cross-sectional association between maternal social support and PSE in our sample, theory of self-efficacy as well as some empirical findings suggest there may be an association. It may be possible that in the moment perceptions of social support may be associated with PSE in that same moment. Future studies should therefore investigate this association dynamically. Similarly, we did not examine dynamic associations between maternal sleep quality and PSE. In our sample, we did not find a cross-sectional association between sleep quality (over the previous month) and PSE. However, it is possible that sleep quality from the night before may affect perceptions of PSE the following day. Future studies of maternal sleep and PSE would benefit from examining these associations using intensive longitudinal methods. In addition, future research should examine how specific infant behaviors are related to PSE in the moment and over time.

Additional Future Directions

The current study examined separate, cross-sectional associations between a set of maternal characteristics (and infant characteristics, for Aim One) and PSE. However, future studies that examine the additive or interactive role of these correlates have the potential to further enhance our understanding of PSE. Findings from several studies support taking this approach. In the context of depression, mothers with depression report more parenting stress, more daily hassles, and less social support than mothers without depression (Gelfand et al., 1992). Fox and Gelfand (1994) compared stressed and dysphoric mothers to non-dysphoric mothers and found that mothers categorized as stressed-dysphoric had significantly lower PSE than non-stressed, non-dysphoric mothers. Researchers also find mothers' sleep qualities to be associated with symptoms of depression in mothers of infants (Goyal et al., 2007; Huang et al., 2004; Hunter et al., 2009) and to predict maternal mood and stress (Meltzer & Mindell, 2007). In terms of PSE specifically, PSE in the presence of high depression was associated with lower parental warmth and higher parental hostility (Wade et al. 2012) and PSE mediated the association between fatigue and overreactive discipline (Lesniowska et al., 2016). Taken together, these findings suggest that maternal characteristics likely work together to predict PSE. Future studies should examine how these characteristics may interact to predict PSE.

In addition, the current study took the important first step of evaluating PSE as a dynamic construct and examining how fluctuations in characteristics of maternal distress (symptoms of depression and anxiety, mood, and stress) were associated with PSE in the moment and over time. An important next step, with the current dataset, is to consider questions of directionality; that is, questions of whether elevations in depression/anxiety, mood, and stress are more likely to precede or to follow lower PSE. Knowledge of such sequences, i.e. which came first, has implications for which may contribute to the other. Use of cross-lagged models would allow us to assess bi-directional associations between PSE and answer these important questions. Similarly, future studies should make use of experimental designs to further assess causal relationships between PSE and its correlates. Preliminary experimental findings from

our lab suggest that induction of sad mood predicted a decrease in PSE (McElwee, 2020; unpublished manuscript). Continued use of novel methodological approaches such as EMA and experimental designs is important to further enhance our understanding of PSE.

Our findings also have clinical significance that provide direction for future studies. First, clearer understanding of the dynamics in mothers provides support for PSE as a target of intervention. Specifically, our findings that PSE beliefs are dynamic, or variable over the course of the day and week, suggest that they may also be modifiable. Further, our findings give strong clues as to what might influence improvement in PSE. Published research from intervention studies (Hoza et al., 2000; Miller-Heyl et al., 1998; Tucker et al., 1998) provides support for direct and indirect benefits of enhancing self-efficacy. A study examining the efficacy of family support intervention identified PSE as a key mechanism of change in the intervention, such that increases in PSE helped explain the significant increases in parental self-appraisals and democratic child-rearing practices, as well as in corresponding decreases in harsh discipline (Miller-Heyl et al., 1998). Further, parents' feelings of competence increased significantly over the course of the intervention. In addition, a study of the long-term efficacy of a behavioral parent training intervention found that mothers' PSE increased significantly over the course of the intervention (Tucker et al., 1998). In terms of indirect benefits, fathers', but not mothers' baseline PSE predicted children's subsequent more positive treatment response in a study of treatment for ADHD (Hoza et al., 2000).

Our use of ecological momentary assessment methods also provides preliminary support for the use of mobile phone-based interventions, or ecological momentary interventions (EMI). A review of this kind of intervention argued that EMIs improve on more traditional intervention approaches by providing deeply personalized interventions created for the user in the moment (Mohr et al., 2014). Our findings could inform the development of an EMI designed to enhance PSE. Specifically, our findings that in the moment, higher symptoms of depression and anxiety, lower positive mood, higher negative mood, and higher perceived stress are all associated with lower PSE suggest that these occasions may be a

particularly fruitful time for the dissemination of an intervention aimed to enhance or intervene on PSE. For example, an EMI for PSE could instantaneously disseminate an intervention protocol designed to enhance PSE when mothers report high levels of depression and anxiety symptoms, negative mood, or perceived stress. As one example of this approach, there is preliminary support for a mobile phone based intervention for depression, anxiety and stress, called "myCompass," which includes fully- automated, mobile phone-based interactive psychotherapy modules, symptom tracking, short motivational messages, and symptom tracking reminders (Whitton et al., 2015). Use of the short motivational messages and the symptom tracking feature were found to be associated with significant improvements in anxiety and functional impairment after controlling for baseline symptom severity (Whitton et al., 2015).

Development of mobile or internet-based interventions may be especially important for mothers with perinatal depression, who have been found to view structural factors as the biggest barrier to accessing treatment (O'Mahen & Flynn, 2008). In line with this idea, mothers with postnatal depression have reported that the flexibility and anonymity of internet based interventions fit their postnatal circumstances (O'Mahen et al., 2015). In addition, given stigma related to depression and treatment of mental disorders (Clement et al., 2015), mothers with depression may be more open to phone based interventions as well as those that target their PSE beliefs, relative to interventions where they are identified based on their depression or anxiety. For example, a study of women's attitudes and perceived barriers to treatment for perinatal depression found that 43% of mothers in their sample viewed stigma as a barrier to treatment (Goodman, 2009). Phone based interventions or EMIs targeted toward parenting may be associated with less stigma and fewer barriers, allowing more mothers with depression to access treatment. Taken together, use of mobile technology may enhance dissemination of strategies to intervene in PSE.

Conclusion

In conclusion, we replicated and extended previous findings on the associations among PSE and various maternal and infant characteristics. We built on the literature on depression and PSE by

examining comorbid depression and anxiety in mothers, which has long been neglected. We tested fundamental yet previously unanswered questions related to the stability of PSE and found empirical support for the theory of parenting self-efficacy as a dynamic construct among first time mothers of infants. Mothers in our study demonstrated significant variability in their PSE beliefs over the course of the day, the course of the study, and in relation to intrapersonal variability in symptoms of depression and anxiety, positive and negative mood, and perceived stress.

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Table 1. Sample Demographics

Variable	Final Sample (n = 155)	Excluded (n = 66)	Statistic
Maternal			
Maternal Age, M (SD)	31.75 (4.30)	30.26 (5.19)	$t(1, 219) = 2.22$*
Maternal Race/Ethnicity, %			$\chi^2(1,4) = 0.34$
African American	7.8	7.6	
Asian	2.6	6.1	
Caucasian	81.0	71.2	
Hispanic/Latinx	2.0	3.0	
Other	6.5	12.1	
Marital Status, %			$\chi^2(1,4) = 0.10$
Married	87.8	79.0	
Separated	2.7	0.0	
Single Parent	2.7	4.8	
Living with unmarried partner	6.1	16.1	
Divorced and Remarried	0.7	0.0	
Family Income, %			$\chi^2(1,5) = 0.17$
Under $25,000	5.6	11.9	
$25,000-$49,000	7.7	6.8	
$50,000-$74,000	13.3	18.6	
$75,000- $99,000	21.7	23.7	
$100,000- $124,000	11.9	16.9	
$125,000 and above	39.9	22.0	
Education Level, %			$\chi^2(1,5) = 0.38$
High School Diploma/GED	2.0	4.8	
Some College	8.8	9.7	
College Degree	30.4	41.9	
Some Graduate School	4.7	4.8	
Graduate School Degree	53.4	38.7	
Other	0.7	0.0	
Employment Status, %			$\chi^2(1,3) = 0.22$
Not employed outside of the home	20.4	16.1	
Employed Part Time	10.9	17.7	
Employed Full Time	67.3	61.3	
Employed Full Time and second job	1.4	4.8	
Baby			
Age (months), M (SD)	6.44 (1.95)	6.21 (3.33)	$t(1,219) = 0.65$

Note. * $p < 0.05$

Table 2. Means and Standard Deviations of Baseline Variables

Variable	Final Sample (n = 155)	Excluded (n = 66)	*t*
PSOC	70.55 (12.12)	69.69 (12.56)	0.48
DASS_stress	11.32 (8.53)	30.26 (5.19)	-1.33
DASS_anx	4.42 (5.23)	7.45 (8.08)	-2.83**
DASS_dep	6.01 (6.82)	7.86 (8.96)	-1.51
MSPSS	5.82 (1.08)	5.59 (1.34)	1.32
IBQ_eff	5.04 (0.64)	5.24 (0.83)	-1.70
IBQ_neg	4.00 (1.02)	4.20 (1.03)	-1.30
IBQ_sur	4.63 (0.96)	4.78 (0.84)	-1.02
PSQI	7.87 (3.55)	5.29 (3.52)	4.89***

Note. **Correlation significant at the $p < 0.01$ level. ***Correlation significant at the ***$p < 0.001$ level. PSOC= Parenting Sense of Competence Scale; DASS = Depression, Anxiety, and Stress Scale; MSPSS = Multidimensional Scale of Perceived Social Support; IBQ = Infant Behavior Questionnaire, Revised, Very Short Form; PSQI = Pittsburgh Sleep Quality Index.

Table 3. Correlations Among Baseline Variables

	PSOC	DASS_stress	DASS_anx	DASS_dep	MSPSS	IBQ_eff	IBQ_neg	IBQ_sur	PSQI
DASS_stress	-.27**								
DASS_anx	-.14	.74***							
DASS_dep	-.24**	.76***	.75***						
MSPSS	.13	-.18*	-.16	-.26**					
IBQ_eff	.23**	.00	.03	-.02	.12				
IBQ_neg	-.25**	.23**	.18*	.20*	-.14	.10			
IBQ_sur	.06	.17*	.15	.19*	.06	.44***	.24**		
PSQI	-.10	.02	.09	.04	-.09	-.05	.22*	-.11	
Response Rate	-.06	-.04	-.20*	-.12	.01	.14	.08	.09	-.03

Note. *Correlation is significant at the 0.05 level (2 – tailed). **Correlation is significant at the 0.01 (2 – tailed) level. ***Correlation is significant at the 0.001 (2 – tailed) level. PSOC= Parenting Sense of Competence Scale; DASS = Depression, Anxiety, and Stress Scale; MSPSS = Multidimensional Scale of Perceived Social Support; IBQ = Infant Behavior Questionnaire, Revised, Very Short Form; PSQI = Pittsburgh Sleep Quality Index.

Table 4. Overall Means, Standard Deviations and Numbers of Surveys for EMA Variables by Timepoint

	PSE	PHQ-4	Positive Mood	Negative Mood	PSS-4
Time of Day					
Morning	13.27 (3.01)	1.85 (2.06)	2.74 (0.89)	1.86 (0.74)	4.43 (2.74)
N	*541*	*537*	*535*	*537*	*503*
Afternoon	13.30 (3.07)	1.70 (2.14)	2.86 (0.90)	1.84 (0.75)	4.33 (2.90)
N	*680*	*682*	*669*	*681*	*636*
Evening	13.54 (3.07)	1.48 (2.01)	2.87 (0.91)	1.73 (0.91)	4.16 (2.77)
N	*659*	*655*	*651*	*654*	*615*
Night	13.62 (3.06)	1.40 (2.01)	2.76 (0.92)	1.68 (0.70)	3.93 (2.96)
N	*669*	*665*	*662*	*669*	*625*
Day					
One	13.11 (2.99)	1.62 (2.12)	2.82 (2.70)	1.77 (0.76)	4.23 (2.80)
N	*414*	*410*	*413*	*415*	*375*
Two	13.34 (3.19)	1.71 (2.05)	2.69 (0.92)	1.78 (0.76)	4.53 (2.8)
N	*398*	*391*	*389*	*398*	*365*
Three	13.44 (2.89)	1.54 (1.97)	2.78 (0.92)	1.70 (0.70)	4.14 (2.69)
N	*366*	*369*	*361*	*364*	*340*
Four	13.55 (3.07)	1.60 (2.10)	2.82 (0.93)	1.76 (0.67)	4.20 (2.88)
N	*364*	*363*	*360*	*360*	*339*
Five	13.69 (3.18)	1.70 (2.24)	2.90 (0.94)	1.73 (0.70)	3.94 (3.04)
N	*345*	*343*	*325*	*333*	*332*
Six	13.42 (2.99)	1.37 (1.87)	2.80 (0.95)	1.74 (0.72)	3.96 (2.80)
N	*334*	*334*	*325*	*333*	*311*
Seven	13.44 (3.06)	1.60 (2.06)	2.81 (0.91)	1.77 (0.73)	4.37 (2.95)
N	*328*	*329*	*329*	*329*	*317*

Note. For Time of Day, maximum possible N is 1085. For Day, maximum possible N is 620. PSE= three items from the Parenting Sense of Competence Scale. PHQ-4= Patient Health Questionnaire, 4. PSS-4= Perceived Stress Scale, 4.

Table 5. Correlations Among EMA Variables Across All Time Points

	PSE	PHQ-4	Positive Mood	Negative Mood
PHQ-4	-.27***			
Positive Mood	.38***	-.49***		
Negative Mood	-.33***	.73***	-.43***	
PSS-4	-.40***	-.68***	-.55***	.61***

Note. ***Correlation is significant at the 0.001 level.

Table 6. Influence of Potential Covariates on PSE

Fixed Effect	Coefficient	*SE*	*t* ratio
Baby Sex	-0.34	0.39	-0.87
Baby Race	-0.09	0.14	-0.67
Maternal Race	-0.29	0.16	-1.82
Marital Status	0.24	0.17	1.38
Family Income	0.04	0.14	0.27
Employment Status	-0.41	0.24	-1.67
Education Level	-0.58	0.19	-3.01*

Note. *Test statistic is significant at the 0.05 level.

Table 7. Hierarchical linear models of Parenting Self- Efficacy

Fixed Effect	Coefficient	*SE*	*t* ratio
Time of Day	0.12	0.03	3.28***
Day	0.08	0.03	2.20*
Depression/Anxiety	-0.32	0.05	-6.97***
Time of Day slope	0.08	0.04	2.32*
Day slope	0.06	0.33	1.92
Positive Mood	0.88	0.12	7.35***
Time of Day slope	0.12	0.3	3.54***
Day slope	0.06	0.03	2.16*
Negative Mood	-0.99	0.12	-8.03***
Time of Day slope	0.05	0.03	1.71
Day slope	0.06	0.03	1.84
Perceived Stress	-0.24	0.03	-7.54***
Time of Day slope	0.09	0.04	2.42*
Day slope	0.07	0.03	1.93

Note. *Test statistic is significant at the 0.05 level. ***Test statistic is significant at the 0.001 level.