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MAPPING MATERNAL EMOTION REGULATION IN THE CONTEXT OF CHALLENGING CHILD BEHAVIORS

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ABSTRACT

Research has increasingly recognized that parental emotion regulation influences whether parents respond sensitively to their children in challenging parenting situations. However, studies of parental emotion regulation often conceptualize and measure it as a trait-like ability, rather than examining the actual processes of regulation in the moment of parenting. To address this gap, this dissertation investigated how the relationship between mothers' emotional states and their behavioral responsiveness to their children could reflect inter-individual differences (Study 1) and dynamic intra-individual processes (Study 2) of maternal emotion regulation. In addition to subjective emotional experiences, this work examined mothers' psychophysiological responses (i.e., RSA, a marker of parasympathetic activity) to build a multidimensional account of maternal emotion by capturing their readiness for action in the moment of parenting that is unobservable and often unconscious. Two studies were conducted using data collected from 157 mothers and their preschool-aged children during a Wait Task, in which mothers told their children to wait for mothers to complete work before children could open an appealing gift.

Study 1 examined how inter-individual differences in mothers' subjective negative emotions and average RSA reactivity jointly predicted their overall responsiveness during the task, and whether these associations were moderated by mothers' self-reported strategies to manage their negative emotions. In this community sample, mothers whose children were more challenging reported experiencing more negative emotions during the task, but also demonstrated higher levels of responsiveness. After accounting for observed challenging child behaviors, mothers' subjective negative emotions and average RSA reactivity were not associated with observed maternal responsiveness. However, mothers' resting RSA and attempts to suppress their negative emotions moderated these associations. The findings suggest that mothers' internal emotional experiences and psychophysiological responses are not necessarily related to actual

parenting behaviors. Rather, the extent of these relations may vary across mothers as a function of their regulatory capacity (e.g., basal parasympathetic functioning) or strategies to manage emotions (e.g., suppression).

Study 2 incorporated theoretical advances in the study of emotion regulation with the specific demands of parenting to conceptualize the intra-individual processes of parental emotion regulation. While the moment-to-moment processes of regulation are hard to measure directly, they may be inferred from the dynamic relations between perturbations to parents' internal emotional equilibrium (e.g., lower RSA) and their actual parenting behaviors. It was hypothesized that these dynamic relations would manifest as ongoing negative feedback loops (i.e., perturbations to parents' internal equilibrium would give rise to responsive parenting behaviors, which would, in turn, facilitate the restoration of internal equilibrium), enabling parents to adapt to both external and internal demands in challenging parenting situations. Analyses based on second-by-second time-series data of maternal RSA and responsiveness during the Wait Task confirmed the presence of the hypothesized negative feedback processes in this sample. Furthermore, the inter-individual differences in these dynamic processes showed unique associations with mothers' overall subjective emotions and responsiveness during the task, their use of strategies to manage negative emotions, and self-reported parenting stress. These findings elucidate the multidirectional dynamics underlying mothers' emotion regulation in the challenging moments of parenting.

In summary, this dissertation demonstrates how the relationship between indicators of parents' emotional phenomena and their actual parenting behaviors, both at the inter-individual and intra-individual levels, could inform us about parental emotion regulation when facing child-related challenges. Together, the two studies illustrate the value of a context-specific and

dynamic approach to examining parental emotion regulation and point out potential mechanisms that could be targeted to promote parental responsiveness and optimal parenting experiences.

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Chapter 1

General Introduction

Models of the development of self-regulation in early childhood point to parent-child interaction as an important context for children to learn socially appropriate behaviors and self-regulatory skills (Kochanska, 1997; Kopp, 1982; Thompson, 2014). When children struggle to cope with frustrating situations independently, parental responsiveness - attending and tailoring behaviors to children's interests and needs – is thought to help children internalize behavioral rules and regulatory strategies, and in the long-term contribute to their self-regulation and psychosocial adjustment (Bernier et al., 2010; Kochanska & Murray, 2000; Wilson & Durbin, 2013). Responding sensitively to children's needs requires parents to regulate their own negative emotions, especially when children's behaviors are hard to manage. The field of family studies has increasingly recognized that parental emotion regulation influences parenting behaviors (Hajal & Paley, 2020; Crandall, Deater-Deckard, & Riley, 2015). Yet little is known about how parents self-regulate in the challenging moments of parenting, and how their regulatory processes unfold to shape their emotions and behaviors in real-time. The current dissertation aims to address this gap through two empirical studies examining the inter-individual differences and intra-individual processes of mothers' self-regulation of emotions in the context of challenging child behaviors. Before describing the two studies, I briefly review the research to date to illustrate why it is important to understand factors that shape parental responsiveness and summarize the theoretical and empirical foundations for understanding parental emotion and emotion regulation in the context of challenging child behaviors.

Parental responsiveness in the context of challenging child behaviors

Parental responsiveness has been conceptualized as a component of broader constructs related to parenting and parent-child relationships, including parental sensitivity, emotional availability, and mutually responsive orientation (Ainsworth, Blehar, Waters, & Wall, 1978; Biringen, 2000; Kochanska, 2002). Drawing from Kochanska's work that focuses on toddler and preschool years (Kochanska, 1997; Kochanska & Murray, 2000), I operationalize parental responsiveness as a dimension reflecting the extent to which parents attend and tailor behaviors to children's interests and needs, that is, whether parents' behaviors reflect attentiveness to, interest in, and acknowledgment of children's needs, versus disregard of their needs.

Across the first three years of life, children typically develop the basic cognitive and neurophysiological capacities that support the control of emotions and behaviors (Rothbart, Sheese, Rueda, & Posner, 2011; Porges, Doussard‐Roosevelt, Portales, & Suess, 1994). The ensuing preschool years normally see growth in committed behavioral compliance and decreases in negative emotions in frustrating situations (Cole et al., 2011; Kochanska, Aksan, & Koenig, 1995), which prepare children for successful adjustment at school entry (Ursache, Blair, & Raver, 2012). Parental responsiveness is argued to contribute to these developmental changes by promoting children's internalization of behavioral rules and regulatory skills endorsed or modeled by their parents (Kochanska & Murray, 2000; Parpal & Maccoby, 1985). Meanwhile, parental responsiveness provides external support that helps children cope with frustrating or frightening situations, which may divert them from experiencing prolonged, dysregulated arousal that interferes with normative self-regulation development in the long run (Calkins, 2011; Thompson, 2014). Correlational evidence supports a longitudinal association between inter-individual differences in parental responsiveness and growth in children's ability to control attention and behaviors across the preschool years (e.g., Graziano, Calkins, & Keane, 2011; Merz, Landry,

Montroy, & Williams, 2017). Little has been done to examine the momentary effects of parental responsiveness on children's emotions and behaviors, although there have been preliminary findings that when preschool-aged children experience frustration and disappointment, parental scaffolding in deploying regulatory strategies increases children's regulatory behaviors and reduces their negative emotions in the ensuing moments (Morris et al., 2011; Putnam, Spritz, & Stifter, 2002).

Given the potential role of parental responsiveness in the development of children's self-regulation, it is critical to understand how parents manage to, or fail to, respond sensitively to their children. Parents of toddlers and preschool-aged children constantly face challenging situations evoked by child behaviors in everyday life. These behaviors, disruptive or innocuous, may simply reflect children's ability and psychological needs at this developmental stage (e.g., limited ability to cope with frustration independently, autonomy-seeking). However, parents typically describe these situations as challenging and stressful, especially when they need to attend to multiple tasks or manage conflicting demands (e.g., working at home while attending to a young child; Crnic & Low, 2002; Kwon, Han, Jeon, & Bingham, 2013). Studies have documented considerable inter-individual differences in how parents react in the context of challenging child behaviors, including the extent to which they turn to harsh parenting or withdraw from attending to their children, which would place parental responsiveness at risk (e.g., Hajal, Teti, Cole, & Ram, 2019; Ravindran, McElwain, Berry, & Kramer, 2018). These findings point to a need to understand the proximal psychological processes that motivate or interfere with parental responsiveness in the challenging moments of parenting, in order to identify mechanisms that could be targeted to improve parenting competence.

Parental emotion in the moment of parenting

Because of the emotionally provoking nature of parenting and the role of emotions in motivating behaviors, parental emotion is argued to be an ongoing organizer of parenting behaviors (Dix, 1991; Teti & Cole, 2011). The functional theory conceptualizes emotion as a continuous process of appraising the circumstances and preparing to act to maintain or regain well-being (Frijda, 1986). For instance, anger or irritation is thought to encompass the appraisal that a desired goal is blocked or one's well-being is threatened, and the readiness to act against the block or threat (Carver & Harmon-Jones, 2009). Consistent with this perspective, Dix (1991) proposed that the relation between parents' concerns and the ongoing circumstances activates their emotions, which "brings direction and intensity to behavior" (p. 13).

However, the parental role adds a layer of complexity in understanding parental emotions and their relationship with parenting behaviors. In the context of parenting, parents' concerns can be multifaceted, involving not only their own well-being but also their children's well-being that they normally feel responsible for (Dix, 1991). Dix and colleagues (2004) asked mothers to report their emotions and describe why they felt that way when interacting with their 1-year-olds during a task that frustrated the children. Mothers' responses reflected both self-oriented (e.g., feeling irritated or anxious because their children would not listen to them) and/or child-oriented concerns (e.g., feeling irritated because the task made their children upset, feeling anxious because their children approached a dangerous object) associated with their emotions. Furthermore, the self-reported concerns moderated how mothers' negative emotions were related to their actual parenting behaviors. For instance, maternal anger was related to lower responsiveness to their children only when it was associated with mothers' self-oriented concerns. These findings were replicated in another study that assessed mothers' self-report of emotions when their infants cried (Leerkes & Qu, 2019). Specifically, mothers' anxiety and frustration

related to self-oriented concerns were associated with lower levels of responsiveness, whereas feeling negative emotions out of sympathy (i.e., feeling for their children) was associated with higher levels of responsiveness.

Although Dix's model emphasizes the role of parents' concerns, that is, how parents' emotions are activated, in the variations of parenting behaviors, there have been increasing inquiries about the role of parents' regulation of emotions. In particular, the commonly used self-report measures of emotions only capture parents' conscious experience and often ask parents to summarize their experience during a task, which may include ebbs and flows of emotional responses, using a single score. It is thus difficult to separate activated emotions and subsequent regulatory effects (Cole, Martin, & Dennis, 2004; Teti & Cole, 2011). For instance, when parents are asked retrospectively about why they have felt specific emotions, they may be reporting conscious interpretations or reappraisals of the feeling of arousal, which arguably reflects cognitive processes that may have shaped behavioral reactions, rather than the prepotent activation of emotions. Moreover, a parent who reports feeling irritated about instances of child non-compliance may have quickly looked at the situation differently (e.g., "The rule is too complicated for such a young child to understand. I should just explain it one more time."), which then modifies the prepotent readiness for action and helps the parent maintain sensitive responsiveness. Such regulatory processes may be a critical component of parenting competence, yet it has not been addressed by studies that simply correlated parents' self-reported emotions with their parenting behaviors.

This lack of clarity motivates two emerging directions in the study of parental emotion and emotion regulation:

First, studies have begun to incorporate psychophysiological measures associated with emotional phenomena. Psychophysiological measures provide access to an unobservable and often unconscious level of analysis that reflects how an individual is preparing to engage with the

circumstance. These measures can also be collected continuously and unobtrusively while parents are engaging naturally with their children, capturing parents' readiness for action in the moment of parenting in a more objective way. Thus, measures of parents' psychophysiological responses can complement self-reported measures of subjective feelings in developing a multi-dimensional and dynamic picture of parental emotion and emotion regulation.

Second, instead of viewing parental emotions and parenting behaviors as "causes and consequences" and simply correlating them, more attention is being directed to what may moderate their unfolding relations and how these relations reflect regulation. Studies linking parents' negative emotions to lower responsiveness or more harsh parenting behaviors typically found only small- to medium-sized effects (Leerkes, 2010; Martin, Clements, & Crnic, 2002; Rueger, Katz, Risser, & Lovejoy, 2011). A study also showed that, although parents' emotions were more strongly and consistently associated with their motivation to engage or disengage with the parenting situation, the association with actual engagement or disengagement was relatively weak and inconsistent (Hajal et al., 2019). These findings support the argument that negative emotions per se are not necessarily problematic, and how one regulates them can modify the prepotent emotional reactions and shape behaviors (Cole, 2016; Cole, Ram, & English, 2019). This has inspired researchers to examine moderators of the relation between parental emotions and parenting behaviors (e.g., Rueger et al., 2011), and calls for process-oriented models to understand how self-regulation unfolds to support parental responsiveness in the challenging moments of parenting.

Study descriptions

The current dissertation includes two studies that aim to further the understanding of parental emotion regulation in the context of challenging child behaviors. I argue that parents'

regulation processes modulate the relationship between their internal emotional states and how they engage behaviorally with the situation. Under this overarching hypothesis, the two studies address the inter-individual differences and intra-individual processes respectively, of mothers' self-regulation of emotions. Both studies utilize data collected from mothers and their preschool-aged children (30-60 months) during a laboratory task – the Wait Task – in which children are told by their mothers to wait (while mothers complete questionnaires in the same room) before they can open an appealing gift. The waiting is designed to frustrate young children such that they may violate the rule of the task (i.e., by trying to open the gift), come to the mother for attention, and/or have tantrums during the task – behaviors that would typically be challenging for parents.

Study 1 focuses on the strategies mothers report using when they experience negative emotions during the task, and how these strategies contribute to inter-individual differences in maternal responsiveness. This study first examines how mothers' subjective negative emotions and physiological functioning jointly predict their overall responsiveness to their children during the Wait Task. I then test whether these relations are moderated by mothers' use of strategies in an attempt to manage their own negative emotions.

Study 2 focuses on the intra-individual processes of maternal emotion regulation by examining how the dynamics of mothers' physiological activity and behavioral responsiveness unfold in the moments of children's challenging behaviors. Drawing on the dynamic systems theory, this study conceptualizes mothers' physiological activity and behavioral responsiveness as elements of a system whose dynamic associations are constantly organized by underlying regulatory processes. Accordingly, Study 2 examines (1) the dynamics of mothers' physiological activity as a function of children's challenging behaviors, and (2) the dynamic, bi-directional relations between mothers' moment-to-moment physiological activity and behavioral responsiveness to their children. Furthermore, I test how these intra-individual processes vary

across mothers as a function of inter-individual differences associated with parenting competence and experiences.

Collectively, these two studies explore potential approaches to examining parental emotion regulation in the moment of parenting and understanding its implications for parental responsiveness. Findings will inform prevention and intervention programs that target responsive parenting to improve children's adjustment and well-being, such as Triple P (Sanders, 2012) and Nurse-Family Partnership (Olds, 2006). Specifically, these parenting programs need to locate indicators of risk and resilience associated with inter-individual differences in parental responsiveness, given evidence of its relationship with children's psychosocial development. Furthermore, understanding the intra-individual processes of how parents self-regulate and respond to their children could help identify the timing (e.g., the moments when the level of responsiveness drops) as well as mechanisms (e.g., what regulatory process is involved when parents manage to or fail to maintain the level of responsiveness) that could be targeted to improve parental responsiveness.

Chapter 2

Inter-Individual Differences in Mothers' Emotional Responses, Strategy-Use, and Maternal Responsiveness in a Challenging Parenting Situation

Introduction

In everyday life, it is common for parents to experience negative emotions, such as irritation, frustration, and worry, evoked by challenging child behaviors. These negative emotions are typically thought to be associated with behavioral tendencies characterized by hostility and coercion or avoidance and withdrawal (Frijda, Kuipers, & ter Schure, 1989). However, individuals regulate their emotions, which can prevent them from acting on those prepotent tendencies when they are ill-advised or detrimental for long-term goals (e.g., promoting children's well-being). Therefore, parental emotion regulation likely plays an important role for parents to engage in appropriate parenting when they experience negative emotions in parenting situations (Crandall et al., 2015; Hajal & Paley, 2020).

Studies of parental emotion regulation and other related constructs (e.g., emotional intelligence, executive functioning, effortful control) often conceptualize them as a set of trait-like abilities, measured through questionnaires or computer tasks unrelated to the context of parenting. Little is known about the specific strategies that parents deploy in an attempt to regulate negative emotions in the challenging moments of parenting, and their effectiveness in altering prepotent reactions and supporting parental responsiveness. To address this gap, the current study focuses on mothers' self-reported use of strategies to manage their negative emotions in a challenging parenting situation, and examines how specific strategies moderate the

relation between mothers' subjective negative emotions or autonomic physiology and maternal responsiveness to their children.

Parental negative emotions and parenting

Empirical evidence supports an association, although not a strong one, between inter-individual differences related to parents' negative emotions (e.g., symptoms of affective disorders, trait-like negative emotionality, and state-like negative emotions) and less positive and more negative parenting behaviors (see Rueger et al., 2011 for a review). Among studies focusing on state-like emotional experiences and real-time parenting, one study showed that compared to mothers who reported experiencing little or no negative emotions, those who reported moderate to high levels of negative emotions during a challenging parenting task were less responsive to their toddlers (Martin et al., 2002). Similarly, another study found that mothers whose toddlers showed more misbehaviors during their interaction reported experiencing more negative emotions, which in turn were correlated with more harsh parenting behaviors (Lorber & O'Leary, 2005). It is important to acknowledge that discrete emotions, defined by coordinated patterns of responses across cognitive, physiological, and behavioral systems (Ekman, 1992), could have unique implications for parenting behaviors. For example, anger has been rather consistently linked to harsh and/or disengaged parenting behaviors, whereas parents who experience worry or anxiety may try to respond to children's needs more promptly (Hajal et al., 2019) but also tend to be over-restrictive (Dix et al., 2004; Locke, Campbell, & Kavanagh, 2012). However, as parents often experience mixed and co-occurring emotions (e.g., a parent who is anxious in a parenting situation can easily experience frustration or irritation when child behavior does not meet their expectation; Turner, Beidel, Roberson-Nay, & Tervo, 2003), studies have

commonly used measures that encompass a collection of emotions with negative valence (e.g., anger, anxiety, frustration).

The association between parents' negative emotions and parenting behaviors has considerable heterogeneity that is not fully explained by methodological differences and basic demographic factors such as child age and parent gender (Rueger et al., 2011). Such heterogeneity may reflect inter-individual differences in parents' regulation of negative emotions. For instance, a recent study examined the patterns in mothers' motivations, which were closely associated with their experience of irritation and discouragement, and their actual behaviors in everyday parenting situations (Hajal et al., 2019). One of the identified patterns was characterized by relatively high levels of irritation and discouragement, self-reported motivation to withdraw from interacting with the child, but actual behaviors to attend to the child. This finding provides support for the argument that parents' regulation of emotions can be inferred from the discrepancy between their experience of negative emotions and actual parenting behaviors. Such discrepancy has been linked with inter-individual differences in parenting goals (Leerkes, Crockenberg, & Burrous, 2004), which may direct one's attempts to regulate emotions. A few studies have also shown that parents' executive functioning (e.g., working memory) and effortful control, which is argued to support emotion regulation, is associated with their ability to maintain more sensitive and less harsh parenting even in situations that likely evoke negative emotions (e.g., challenging child behaviors, discipline encounters; Deater-Deckard, Sewell, Petrill, & Thompson, 2010; Sturge-Apple, Jones, & Suor, 2017). What remains unclear, however, is the extent to which these trait-like abilities represent parents' strategies to regulate emotions *in the moment of parenting*, and no study to my knowledge has directly examined how parents' strategy-use in parenting situations moderates the relationship between their emotional experiences and actual responsiveness.

Autonomic functioning and parenting

In addition to subjective experiences, emotional responses also involve reactivity in the autonomic nervous system (ANS; Kreibig, 2010). Measures of ANS responses provide unique insights into individuals' state of arousal in preparation for action that may not be captured by reports of subjective emotional experiences (Britton, Taylor, Berridge, Mikels, & Liberzon, 2006; Hollenstein & Lanteigne, 2014). Furthermore, some indicators of autonomic functioning (e.g., basal parasympathetic activity) have been linked to the capacity for cognitive control (Thayer & Lane, 2009), which may play a role in supporting the regulation of emotions. Therefore, the ANS has been increasingly studied in relation to parenting behaviors. In the current study, I focus on the parasympathetic branch of ANS given its functional relevance to emotional responses, cognitive control, and social behaviors (Butler, Wilhelm, & Gross, 2006; Isgett et al., 2017; Porges, 2003; Thayer, Hansen, Saus-Rose, & Johnsen, 2009). I specifically examine parents' respiratory sinus arrhythmia (RSA), a marker of parasympathetic functioning, both at rest and in response to challenging parenting situations.

Resting RSA

The parasympathetic nervous system functions to inhibit arousal in end organs, conserving and restoring energy to maintain body functioning. Parasympathetic activity is commonly measured by RSA, a measure of heart rate variability as a function of respiration (Berntson, Cacioppo, & Quigley, 1993). Maintaining higher levels of RSA in the absence of environmental novelty or challenge indicates greater parasympathetic control over arousal, and is assumed to support social affiliative behaviors (Porges, 2003). Additionally, higher levels of RSA have been shown to reflect greater activation of the prefrontal cortex that is associated with

executive functioning (see Thayer & Lane, 2009 for a review). Therefore, RSA during resting or non-challenging situations (e.g., watching an emotionally neutral film clip) is often regarded as an indicator of individuals' capacity to inhibit arousal and/or engage in cognitive control. Consistent with this hypothesis, higher resting RSA in adults has been associated with better performance in cognitive tasks (Capuana et al., 2014; Williams, Thayer, & Koenig, 2016). Moreover, adults with higher resting RSA tend to show less expressive behaviors even if they report feeling similar levels of negative emotions with others (Pu, Schmeichel, & Demaree, 2010). This suggests that basal parasympathetic functioning may play a role in the regulation of emotions, although it is unclear whether the connection is through the deployment of specific regulatory strategies involving cognitive control, or a general capacity to modulate physiological arousal. Studies have found that mothers with higher resting RSA are more responsive to their young children (Joosen et al., 2013; Musser, Ablow, & Measelle, 2012). However, parents' resting RSA has not been examined in conjunction with their subjective negative emotions, or as a potential moderator in the relation between self-reported negative emotions and parenting behaviors.

RSA reactivity

RSA reactivity, which is commonly measured as the change in RSA level from resting baseline to a challenging situation, is seen as an indicator of how individuals are reacting to and preparing to engage with the specific situation. When facing emotional challenges, it is typical for adults to show a decrease in RSA (i.e., RSA suppression), which indicates a withdrawal of parasympathetic control, allowing an increase in arousal to support coping behaviors (Porges, 1995). The polyvagal theory proposed that, because parasympathetic control can be re-engaged rapidly, a decrease in RSA is an efficient way to mobilize physiological resources without

compromising the ability to quickly re-inhibit arousal (Porges, 1995, 2007). Due to this functional characteristic and the neuroanatomical overlap with the regulation of social behaviors (e.g., muscle movements related to facial expression and vocalization), parasympathetic reactivity is argued to play a primary role in the flexible modulation of emotional and behavioral responses during social interactions (Porges, 2003).

However, empirical evidence linking RSA reactivity to inter-individual differences in parenting behaviors has yielded mixed findings. Several studies found that a decrease in parents' RSA from resting baseline to a challenging parenting situation (e.g., having to soothe a distressed infant or resolve conflicts with child) was related to more responsive and less harsh parenting behaviors (Joosen et al., 2013; Moore et al., 2009; Sturge-Apple, Li, Martin, Jones-Gordils, & Davies, 2019). These findings were interpreted as reflecting the value of parasympathetically-mediated physiological arousal in supporting parents' emotional and behavioral engagement to respond to children's needs. Meanwhile, there has also been evidence indicating the value of maintaining higher levels of RSA (i.e., smaller decreases compared to baseline), either around the time of challenging child behaviors (Ravindran, 2018) or across the duration of a challenging parenting task (Lorber & O'Leary, 2005), for parents to respond supportively rather than harshly to their children. Some researchers thus argued that a greater decrease in RSA, although not directly correlated with subjective negative emotions (Lorber & O'Leary, 2005), may allow heightened physiological arousal to interfere with parents' problem solving and social affiliative behaviors. Other studies found no association between RSA reactivity across the duration of a parenting situation and parenting behaviors (e.g., Leerkes, Su, Calkins, O'Brien, & Supple, 2017; Zhang, Gatzke-Kopp, & Han, 2021). A possible explanation for these inconsistent findings is that, while RSA reactivity may reflect how parents are physiologically prepared to engage with the situation, its relation with actual parenting behaviors may be modulated by higher-order

cognitive processes. The current study tests this hypothesis by examining whether mothers' use of strategies to manage negative emotions moderates the relation between RSA reactivity and maternal responsiveness.

Parental use of strategies to manage negative emotions

Parents may invoke various strategies in an attempt to regulate their negative emotions in challenging parenting situations, which could have unique implications for their responsiveness to their children. Conceptual and empirical work on general adult emotion regulation has addressed how different strategies influence indicators of emotional phenomena (i.e., subjective feelings, physiological responses, expressive behaviors; Gross, 1998a, 1998b; Webb, Miles, & Sheeran, 2012), as well as how these strategies are associated with psychological well-being (Aldao, Nolen-Hoeksema, & Schweizerb, 2010; Gross & John, 2003). However, the choice and effectiveness of specific strategies may differ by contexts and goals (e.g., making oneself feel better, versus maintaining a harmonious relationship with others; English, Lee, John, & Gross, 2017; Sheppes & Gross, 2012). The context of parenting presents unique challenges for emotion regulation, because we care not only about how a strategy influences parents' own emotional experiences, but also how it supports or interferes with parental responsiveness. Very few studies have examined parental use of strategies when they experience negative emotions in challenging parenting situations – a gap that the current study aims to address. I focus on four common strategies that have a relatively solid research base in the literature of general adult emotion regulation and discuss their potential implications in the context of parenting.

Reappraisal

Reappraisal refers to adjusting one's interpretation and evaluation of an event, and in the case of regulating negative emotions, often involves thinking about an unpleasant situation in a more positive way (Gross, 1998a). Reappraisal is generally regarded as an adaptive regulatory strategy because it attempts to defuse negative emotions at their roots by cognitively reframing the emotionally provoking event (McRae, Jacobs, Ray, John, & Gross, 2012). Empirical evidence, largely based on individual contexts (e.g., participants watching an emotional film alone), has also shown that reappraisal reduces adults' subjective feelings of negative emotions as well as corresponding facial expressions and physiological arousal (e.g., Gross, 1998b; Ray, McRae, Ochsner, & Gross, 2010). When facing challenging child behaviors, parents who experience more negative emotions or show more harsh parenting behaviors often report a negative appraisal bias, that is, perceiving child behaviors as more intentional and disruptive (Dix, Ruble, & Zambarano, 1989; Lorber & O'Leary, 2005). Reappraisal may enable parents to replace such perceptions with more positive ones (e.g., "Waiting is hard for such a young kid and he/she does not mean to do that."), which may help parents be more responsive to their children's needs. Parents' use of reappraisal, both globally and in parenting situations specifically, has been correlated with more supportive and less harsh parenting behaviors, although such associations seem to differ for parents with psychopathological risks (Kohlhoff et al., 2016; Lorber, 2012).

Distraction

Distraction involves attentional selection, that is, to redirect one's attention from emotionally evocative contents toward other contents that are neutral or positive (Kalisch, Wiech, Herrmann, & Dolan, 2006). In individual contexts, distraction has been shown effective in

reducing subjective feelings of negative emotions as well as corresponding facial expressions (Efinger, Thuillard, & Dan-Glauser, 2019; McRae, Hughes, Chopra, & Gabrieli, 2010). However, distraction may also have costs, especially when the emotionally evocative content is an interpersonal situation. When individuals' attention is simply shifted away, they may be less able to process the emotional information in the situation or to actively resolve the conflict (Sheppes, Scheibe, Suri, Radu, Blechert, & Gross, 2014). For example, responding sensitively to children's needs requires parents' awareness and understanding of children's emotional cues and mental states (Leerkes, 2010; Slade, 2005). If parents simply take their mind off of their children's challenging behaviors, the attentional disengagement may impact their responsiveness. Empirically studies have shown that parents often encourage their young children to use distraction when children are distressed (e.g., Morris et al., 2011), but no evidence is available on whether parents use distraction themselves in challenging parenting situations and how it may shape parenting behaviors.

Suppression

Instead of invoking cognitive changes, suppression involves attempting to inhibit subjective feelings and/or conceal expressive behaviors (Gross, 1998a). Although suppression effectively reduces expressive behaviors, at least in the short term, it is less effective in lowering subjective negative emotions and may lead to heightened activation in the amygdala and arousal in the sympathetic branch of ANS (i.e., "fight-or-flight" response; Goldin, McRae, Ramel, & Gross, 2008; Gross, 1998b). Parents' persistent negative emotions and heightened sympathetic arousal are both associated with risks for less supportive and more harsh parenting behaviors (Joosen, Mesman, Bakermans-Kranenburg, & van IJzendoorn, 2013; Rueger et al., 2011; Zhang

et al., 2021). Therefore, parents' attempts to suppress negative emotions may interfere with their responsiveness to their children. This is supported by two experimental studies showing that when parents were instructed to suppress their negative emotions before or during an interaction with their children, they appeared to be less responsive or warm (Le & Impett, 2016; Waters, Karnilowicz, West, & Mendes, 2020). Meanwhile, however, suppression is a commonly used strategy in interpersonal contexts (English et al., 2017), and is argued to have some value in supporting the goal of maintaining a harmonious relationship or promoting the well-being of others (Butler & Gross, 2004). Consistent with this argument, Lorber (2012) found that parents who attempted to suppress their negative emotions in discipline encounters reported using less harsh discipline. Another study also found that parents who used suppression more frequently in everyday life were less likely to use harsh discipline toward children's misbehaviors (Kohlhoff et al., 2016). To synthesize these findings, it is possible that suppressing negative emotions has both benefits and costs in challenging parenting situations. It may reflect parents' effort to not act upon their irritation and frustration (e.g., not to use harsh discipline); however, as the negative feelings and heightened physiological arousal are still present (if not exacerbated), parents' ability to actively respond to children's needs may continue to be compromised.

Rumination

Rumination refers to thinking over and over about one's feelings and related causes and consequences (Papageorgiou & Wells, 2003). Unlike reflective processing where individuals try to understand their emotions from a self-distanced perspective, rumination can immerse individuals with their feelings and associated events in an unconstructive way (Kross, Ayduk, & Mischel, 2005). Engaging in rumination over an unpleasant experience tends to enhance adults'

negative emotions and physiological arousal (Moberly & Watkins, 2008; Ray, Wilhelm, & Gross, 2008). Rumination also correlates with a range of psychopathological disorders (see Aldao et al., 2010 for a review). It is thus regarded as an ineffective and maladaptive regulatory strategy. The evidence further suggests that rumination is associated with lower social skills (Takano, Sakamoto, & Tanno, 2011) and may impact individuals' problem-solving ability in interpersonal contexts (Lyubomirsky & Nolen-Hoeksema, 1995). In the context of parenting, rumination likely compromises parental responsiveness, not only because of its role in sustaining parents' negative emotions, but also because ruminating parents may be entangled in their own feelings and thoughts rather than paying attention to their children's needs.

To summarize, in the models of adult emotion regulation, strategies that invoke cognitive changes to redirect attention or defuse negative emotions (i.e., reappraisal and distraction) are commonly seen as more adaptive than suppressing or pondering over the emotions (i.e., suppression and rumination). However, "adaptiveness" is largely defined by individuals' own well-being in that literature. There has been emerging evidence on how some strategies (e.g., reappraisal and suppression) play out in interpersonal contexts, although findings have been somewhat mixed on their roles in parental responsiveness. The implications of distraction and rumination in the context of parenting are even less understood. Furthermore, except for two experimental studies (Le & Impett, 2016; Waters et al., 2020), most studies linking regulatory strategies to parenting behaviors did not account for how emotionally provoking the parenting situation was (e.g., how challenging child behaviors were), or the degree to which parents experienced negative emotions. Therefore, this study tests whether mothers' use of strategies moderates the relation between their subjective negative emotions or RSA reactivity and the level of maternal responsiveness displayed during a dyadic interaction while accounting for the amount of challenging child behaviors.

Study aims and hypotheses

The current study aims to address the role of mothers' strategy-use in the relations between indicators of mothers' emotional phenomena (i.e., subjective feelings and RSA reactivity) and their actual responsiveness to their children. A series of hypotheses are tested using data collected from mothers and their preschool-aged children during a Wait Task.

Aim 1: Examine the associations among multiple emotional indicators and observed maternal responsiveness

For Aim 1, I first examine the extent to which physiological reactivity (average task RSA reactivity) and self-reported subjective experience reflect similar (i.e., are correlated with one another) or divergent inter-individual differences in mothers' emotional responses. I then examine whether and how mothers' subjective negative emotions, resting RSA, and average RSA reactivity jointly predict the average level of maternal responsiveness during the task, and whether RSA (at rest or reactivity) interacts with mothers' subjective emotions in predicting maternal responsiveness. I hypothesize that greater subjective negative emotion would demonstrate a main effect in association with lower levels of maternal responsiveness, whereas greater resting RSA and a decrease in RSA during the Wait Task would be associated with higher levels of maternal responsiveness (**Hypothesis 1a**). I further hypothesize that the presumably adaptive RSA profile (higher resting RSA, and lower average RSA during the Wait Task compared to the resting level) would serve to weaken the association between subjective negative emotions and maternal responsiveness (**Hypothesis 1b**).

Aim 2: Characterize mothers' strategy-use when experiencing negative emotions

After establishing the sample-average relationships between emotional indicators and maternal responsiveness in Aim 1, Aim 2 characterizes mothers' use of strategies in an attempt to manage their negative emotions, and the extent to which the context-specific strategy-use is associated with commonly measured traits related to adult self-regulation (i.e., effortful control and emotion regulation difficulties). First, I test the hypothesis that mothers would actively invoke a range of strategies – reappraisal, distraction, suppression, and rumination – when they experience negative emotions in response to their children's behaviors. That is, mothers who report experiencing more negative emotions would also report using each of the strategies more (**Hypothesis 2a**). Second, I test the hypothesis that better effortful control and lower levels of emotion regulation difficulties would be associated with more use of the presumably "adaptive" strategies (reappraisal and distraction) and less use of the "maladaptive" strategies (suppression and rumination; **Hypothesis 2b**).

Aim 3: Examine whether strategies moderate the relation between emotional indicators and maternal responsiveness

Aim 3 tests the hypothesis that mothers' strategy-use would moderate how their subjective negative emotions and RSA reactivity are associated with their responsiveness to their children (**Hypothesis 3**). Based on existing evidence, reappraisal is expected to weaken the association between subjective negative emotions and lower maternal responsiveness, whereas rumination is expected to strengthen this association. The roles of distraction and suppression or how strategies may interact with RSA reactivity are less clear, and no specific hypotheses are set.

Methods

Participants

Study 1 uses data drawn from the Development of Self-Regulation Dynamics Project, a cross-sectional study of age differences in young children's self-regulation. Families with children from 30 to 60 months of age were recruited from central Pennsylvania through the Pennsylvania State University Child Study Center participant pool (The FIRSt Families Database), flyers, and community events (e.g., art and craft festivals). Families that expressed interest were contacted by research assistants; eligible families were enrolled and invited for a laboratory visit at the university. In addition to the child being within the desired age range, other inclusion criteria included: (1) no report of developmental delays or health concerns that would interfere with providing valid data (e.g., cognitive limitations, intellectual disability, deafness); (2) the family speaks English well enough to understand and complete study procedures; and (3) at least one caregiver is the child's legal guardian. A total of 158 families completed the laboratory visit. Both caregivers (mother and father in most cases) were invited to participate; of the 158 families, 101 (63.9%) visits were attended by both parents, 56 (35.4%) were attended by mothers only, and 1 (0.6%) visit was attended by the father only. As the current study focuses on a task for mother-child dyads, the one father-only family was not included.

The final sample of the current study was 157 children (49.7% female) between 30 and 60 months of age (M_{age} = 45.08 months, SD = 8.17 months) and their mothers (all biological mothers; M_{age} = 35.19 years, SD = 5.10 years). The children were identified by their mothers as White (95.6%), Asian (2.6%), Black (1.3%), and Native American (0.6%). The families in this sample had an average annual income of $89,875 ($SD$ = $50,303) with a relatively wide range (the 10th and 90th percentiles of family annual income were $35,000 and $150,000). Most of the

mothers were married (89.6%) at the time of the visit. Most mothers had attained a bachelor's degree or above (78.2%); 53.5% of mothers worked full-time, 23.6% worked part-time, and 22.9% were not employed at the time of the visit.

Procedures

Research assistants contacted enrolled families to collect their demographic information and schedule a 4-hour laboratory visit. Before the visit, parents were asked to complete a packet of questionnaires through an online survey platform (Qualtrics, Provo, UT). Upon arrival at the laboratory, the family was met by a research assistant who explained the purpose of the study and general procedures. The parent(s) then signed consent forms. The research assistants measured each family member's height and weight and applied electrodes connected to the ambulatory device that recorded physiological signals (described in the Measures section; Mindware Technologies LTD., Westerville, OH). The child and the parent(s) then participated in a series of tasks, sometimes alone and sometimes in pairs (i.e., mother-child or father-child dyad), over the next 3-4 hours (see Figure 2-1). The tasks commonly used to assess children's and adults' self-regulation (some were designed to elicit fear or frustration) were alternated with enjoyable tasks (e.g., free play, snack break). The parent(s) completed another set of questionnaires using paper-pencil or through Qualtrics during the visit. At the end of the visit, the parents were debriefed, and the family was reunited. After the electrodes were removed, the child received all of the earned rewards and the family received compensation. All study procedures were approved by the Institutional Review Board of the Pennsylvania State University (Project name: The Development of Self-Regulation Dynamics; Study ID: STUDY00005112).

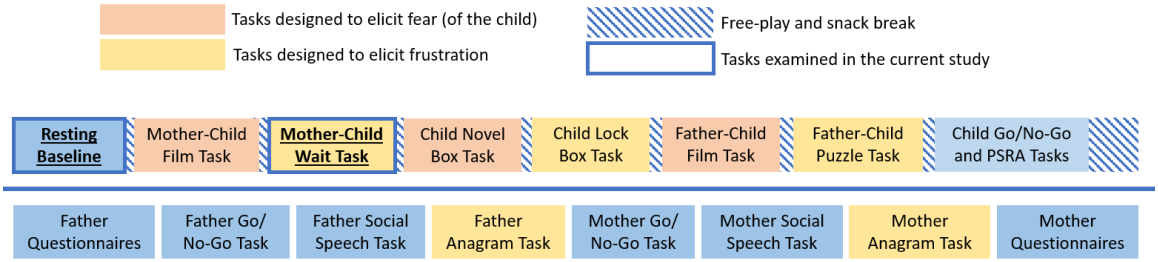

Figure **2-1**: The order of tasks during the laboratory visit.

Notes. PSRA = The Preschool Self-Regulation Assessment Battery (Smith-Donald, Raver, Hayes, & Richardson, 2007). If only one parent participated in the study, the tasks involving the other parent were not administered.

The current study uses data collected during a baseline task, during which the mother and the child were asked to sit quietly in a room for 2 minutes, and a mother-child Wait Task (Cole et al., 2011; Vaughn, Kopp, & Krakow, 1984). At the start of the Wait Task, the child and the mother were seated at separate tables in the same room. The child was provided with a boring and broken toy (a white toy horse with missing legs), and the mother was given questionnaires to fill out. The research assistant then placed a package wrapped in shiny and rustling paper on the child's table and told the child that there was a surprise gift inside. The mother received written instructions: "before you start working, and right after the research assistant leaves the room, tell the child to wait to open the gift until you finish your work", and was instructed to act as they normally would when the mother must finish some work and the child must wait. The research assistant placed a 3-minute sand timer on the mother's table before leaving the room. This task included three segments (3 minutes each); after each of the first two segments, the research assistant entered the room, said to the parent "Oh, you need more time", and reset the timer before leaving again. At the end of the third segment, the research assistant returned and the child was allowed to open the gift.

Measures

Challenging child behaviors

The degree to which children's behavior would challenge a typical adult was rated second-by-second during the Wait Task. The rating scale (see Appendix A) was adapted from work by Lorber and O'Leary (2005). Specifically, I adopted their operational definitions of negative child behaviors in the context of a waiting task (e.g., bids for parent's attention, violation of task rules or behaviors that reflect a difficulty to wait, expression of negative emotions, disruptive behaviors), but converted the system from binary decisions (whether the child is showing a behavior) to an ordinal rating of how challenging children's behaviors are. Children's behaviors were rated independent of their parents' behaviors.

Using the Datavyu software (Datavyu Team, 2014), trained research assistants watched the videotape of the Wait Task and rated children's behaviors second-by-second on a 5-point scale (from 0 "Not at all challenging" to 4 "Highly challenging"). Each family's videotape was rated independently by a trained research assistant, and 32 randomly selected videotapes (20% of the sample) were double-coded to check inter-rater consistency. The intraclass correlation coefficient (ICC) across all double-coded videotapes was .83, suggesting relatively high levels of agreement between raters (ICC 2 is selected to assess raters' absolute agreement during each second; Shrout & Fleiss, 1979). ICC was also calculated for each double-coded family, and in cases where ICC was below .70 (2 of the 32 families), the two raters discussed the discrepancies and produced consensus ratings that were included in the final data. Observational data were available for 156 of the 157 families because the videotape of 1 family did not have audio due to device malfunction.

To represent the inter-individual differences in how challenging the children were, the second-by-second ratings were averaged across the Wait Task for each family and used in the analyses. Of a possible range of 0 to 4 (0 represents no challenging behaviors at any second, and 4 represents being highly challenging throughout the entire task), the actual score ranged from 0 to 2.46 (M = 0.59, SD = 0.47). Only 1 of the participating children showed no indicator of challengingness at all (score = 0), while the rest of the sample showed at least some challenging behaviors during the task, and the proportion of task time children showed challenging behaviors (i.e., none-zero ratings) ranged from 0% to 87%, with a sample average of 36%.

Maternal subjective experience of negative emotions

During the Wait Task, mothers completed questionnaires, including one in which they reported their emotions about how the child was handling the wait. Participating mothers rated the extent to which they felt each of 8 positive and 12 negative emotions on an 11-point Likert scale ranging from 0 "not at all" to 10 "strongly". An average score across the 12 negative emotions (i.e., impatient, annoyed, irritated, angry, nervous, tense, anxious, scared, bored, disappointed, discouraged, sad; see Figure 2-2 for the level of each discrete emotion) was then calculated to represent each mother's subjective experience of negative emotions during the Wait Task (possible range = 0 - 10). There was good internal consistency across the twelve items (Cronbach's α = .88). On average, mothers reported feeling quite low levels of negative emotions (M = 1.30, SD = 1.25) and used only the lower half of the scale (Range = 0 - 5.33).

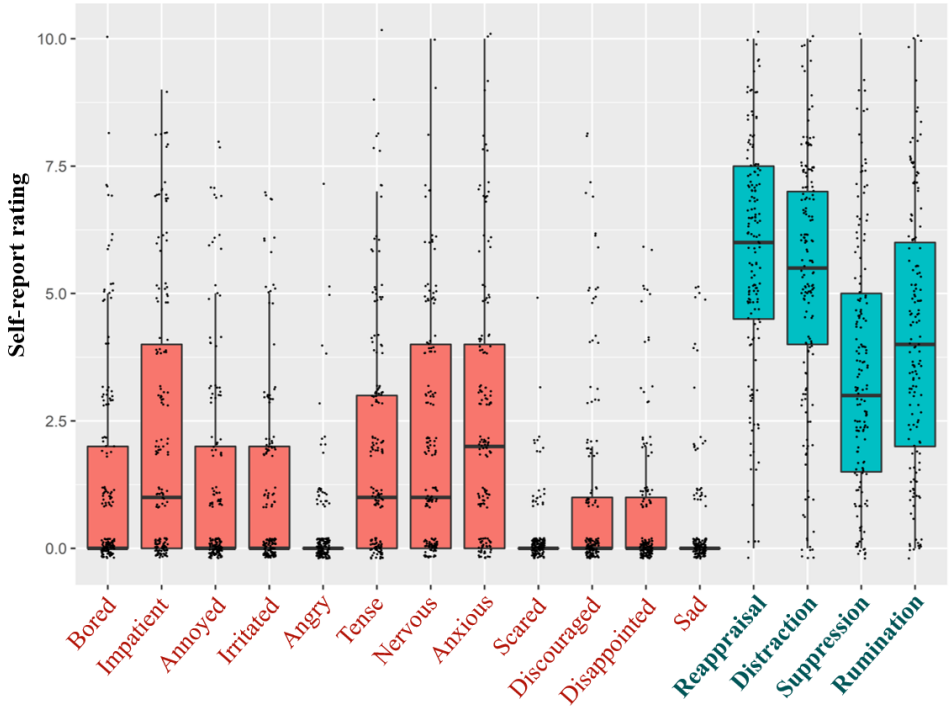

Figure **2-2**: Mothers' negative emotions and strategy-use during the Wait Task.
Notes. Scores of individual mothers are represented by dots.

Maternal strategy-use

During the Wait Task, mothers also rated the extent to which they used specific strategies to manage the negative emotions they reported. The questionnaire consists of 16 items, including 2 items for each of eight types of strategies. Only the 8 items reflecting the strategies that the current study was interested in (i.e., reappraisal, distraction, suppression, rumination) were examined here (see Appendix B for the items). Mothers rated how much they used the strategy described in each item on an 11-point Likert scale (from 0 "not at all" to 10 "very much"). The internal consistency for the 2 items measuring each strategy was evaluated through the coefficient of correlation between the items (i.e., equivalent to a split-half reliability test), corrected by the

Spearman-Brown formula (Eisinga, Grotenhuis, & Pelzer, 2013). The Spearman-Brown coefficient was .80 for reappraisal, .50 for distraction, .60 for suppression, and .66 for rumination. An average score was calculated for each strategy across ratings of the 2 items (possible range = 0-10). For all four strategies, mothers' responses spread the full range of the scale, with sample averages indicating moderate levels of strategy-use (see Table 2-1 and Figure 2-2 for the descriptive information of specific strategies).

Resting RSA and RSA reactivity

Mothers' resting RSA and RSA reactivity were measured during the 2-minute resting baseline and the approximately 9-minute Wait Task. Electrocardiography (ECG) data were collected using Mindware Technologies ambulatory devices and BioLab software (version 3.1; Mindware Technologies LTD., Westerville, OH) from three disposable cardiac electrodes placed over participants' distal right collar bone, lower left rib, and lower right rib. Signals were recorded at a sampling frequency of 500 Hz. Then, ECG data were imported into Mindware's HRV software (version 3.1.5; Mindware Technologies LTD., Westerville, OH), which identified R peaks algorithmically and produced inter-beat interval (IBI) series. Trained research assistants visually inspected all the ECG data, and manually corrected erroneously identified or missed R peaks when wave forms were clear. When signals were lost or corrupted by noise such that wave forms could not be identified, research assistants were instructed to interpolate one missing beat at most (using the Midbeat function in Mindware); when the corrupted signals likely included two or more beats, data points between the nearest valid R peaks were marked as missing. Data were then reviewed by trained research staff to verify research assistants' edits. Participants' respiration rate was estimated through impedance cardiography collected through four additional

electrodes, which was used to ensure that respiration rate remained within the targeted frequency band for calculating RSA (0.12-0.40 Hz for adults; Berntson, Quigley, & Lozano, 2007). The cleaned and verified IBI series was then output from Mindware HRV for the calculation of RSA.

RSA calculation was conducted using the RHRV package (Martínez et al., 2017) in R (R Core Team, 2016). The input IBI series were first filtered to identify outliers based on a pre-set possible range of IBI values (300-2000 milliseconds) as well as the algorithm of the FilterNIHR function in RHRV (Martínez et al., 2017; Vila et al., 1997). When outliers were removed from the IBI series, a separate variable tracked accumulated time across the task, so that removing outliers would not cause misalignment between the IBI series and the actual flow of time. Based on the filtered IBI data, a series of equidistant IBI values were generated at a sampling frequency of 4 Hz through cubic spline interpolation. The interpolation generated imputed IBI values for portions of missing data; however, for portions of missing data that were ≥ 10 seconds, the interpolated values were removed to maintain conservative precision of imputation.

The average RSA across each 30-second epoch during the baseline and the Wait Task was computed based on the interpolated, equidistant IBI series. Specifically, a Hamming window taper function was applied to each non-overlapping, 30-second epoch of data, and short-time Fourier transform was used to obtain the corresponding spectral density of power in heart rate variability. The average RSA for each epoch was then computed as the natural log of power within the frequency band of 0.12-0.40 Hz. RSA was not calculated for epochs that were shorter than 30 seconds (i.e., at the end of the task) or those that contained any missing data. Mothers' resting RSA and task RSA were calculated by averaging the 30-second RSA values across the baseline task and the Wait task, respectively. Average RSA reactivity was then calculated by subtracting resting RSA from task RSA. That is, positive RSA reactivity values represented

increases in RSA, whereas negative values represented decreases in RSA from baseline to the Wait task.

A paired-sample *t*-test showed that the mothers on average showed lower RSA during the Wait Task compared to the baseline, $t\ (153) = 6.85$, $p < .001$ (see Table 2-1 for the means and standard deviations of resting RSA and task RSA). RSA reactivity ranged from -1.94 to 1.42, suggesting inter-individual differences in whether and how much mothers' RSA increased or decreased during the Wait Task compared to the baseline.

Maternal responsiveness

Maternal responsiveness was measured using an ordinal rating scheme created to assess the extent to which mothers' behaviors reflected attempts to acknowledge and address the child's interests and needs, versus to dismiss or avoid attending to the child (see Appendix C). Using the Datavyu software (Datavyu Team, 2014), trained research assistants watched the videotape of the Wait Task and rated mothers' behavior second-by-second on a 7-point scale ranging from -3 to 3. The upper half of the scale (a rating of 1, 2, or 3) was used for moments when the mother displayed attentiveness to, initiation of interaction, and/or response to the child that reflected different levels of interest in or concern about the child and/or efforts to acknowledge and support the child's interests and needs (see Appendix C for examples). The lower half of the scale (a rating of -1, -2, or -3) was used for moments when the mother's behavior explicitly indicated that they were disinterested in the child's states and/or did not want to interact with the child or provide any help. The middle-point of the scale (a rating of 0) was used for moments when the mother did not show observable indicators of either attending to the child or dismissing the child. Thus, a rating of 0 was typically applied to moments when the mother was simply working on

questionnaires without showing any attention, speech, or behavior toward the child. Generally, higher ratings (e.g., 3) indicate higher levels of responsiveness reflected in parents' behaviors at a given moment, whereas lower ratings (e.g., -3) represent not just a lack of responsiveness, but indicators of actively dismissing or invalidating children's needs (e.g., "Don't bother me!"). Ratings were made based on mothers' body orientation, verbalizations and vocalizations, facial expression (whenever visible), and/or gestures that conveyed the level of responsiveness.

Each family's videotape was rated independently by a trained research assistant, and 31 randomly selected videotapes (20% of the sample) were double-coded to check inter-rater consistency. The ICC across all double-coded videos was .82, indicating relatively high levels of agreement between raters. In a case-by-case check, 4 of the 31 double-coded videotapes had ICCs that were below .70. Consensus ratings were conducted between two raters to produce the final ratings for these 4 families. All mothers showed at least some behaviors toward their children that received non-zero ratings on this scale (i.e., no mother received a rating of 0 throughout the task). To evaluate the overall degree of maternal responsiveness, the second-by-second ratings were averaged across the Wait Task for each mother and used in the analyses. Of a possible range of -3 to 3, the actual score ranged from -0.10 to 1.83 (M = 0.39, SD = 0.31).

Trait-like measures of general adult self-regulation

Maternal emotion regulation difficulties. During the visit, mothers completed the 36-item Difficulties in Emotion Regulation Questionnaire (DERS; Gratz & Roemer, 2004), which assesses difficulties with emotional awareness, understanding, acceptance, regulation, and goal-directed action in daily life. Although the DERS was originally developed based on the significance of emotion regulation deficits in clinical disorders, it has shown good internal

consistency and construct validity among adults in community samples (Gratz & Roemer, 2004; Ritschel, Tone, Schoemann, & Lim, 2015). The DERS could be seen as a measure of trait-like emotion regulation difficulties, as it asks respondents to report their typical experiences in managing emotions, and the scores have shown strong stability when measured repeatedly over weeks or months (Gratz & Roemer, 2004; Rice, Montfort, Ray, Davis, & DeBlaere, 2019).

Six subscales in the DERS assess different aspects of experiences related to emotion regulation, including Nonacceptance of Emotional Responses (6 items; e.g., "When I'm upset, I feel ashamed at myself for feeling that way."), Difficulties Engaging in Goal-Directed Behaviors (5 items; e.g., "When I'm upset, I have difficulty getting work done."), Impulse Control Difficulties (6 items; e.g., "When I'm upset, I lose control over my behavior."), Lack of Emotional Awareness (6 items; e.g., reversely coded "I pay attention to how I feel"), Limited Access to Emotion Regulation Strategies (8 items; e.g., "When I'm upset, I believe that wallowing in it is all I can do."), and Lack of Emotional Clarity (5 items; e.g., "I have difficulty making sense out of my feelings."). Mothers rated each item on a 5-point Likert scale indicating how often the statement applied to them (from 1 "almost never" to 5 "almost always"). All six subscales demonstrated good internal consistency for participating mothers in the current sample (Cronbach's $\alpha = .76 – .93$); there was also good internal consistency across all 36 items (Cronbach's $\alpha = .93$). An average score was calculated across items from all six subscales and was used in the analyses to represent mothers' general emotion regulation difficulties. Of a possible range of 1 to 5, the actual scores ranged from 1.17 to 4.00 ($M = 2.03$, $SD = 0.50$), suggesting adequate variability in emotion regulation difficulties among mothers in the sample.

Maternal effortful control. Mothers completed the Adult Temperament Questionnaire – Short Form (ATQ-SF; Evans & Rothbart, 2007) before the laboratory visit. The current study focused on a factor, identified as effortful control, that emerged consistently in the factor analyses

of ATQ-SF and showed good internal consistency and external validity (Evans & Rothbart, 2007; Laverdière, Diguer, Gamache, & Evans, 2010). The effortful control factor included items from three subscales including activation control (7 items; e.g., “I can make myself work on a difficult task even when I don't feel like trying.”), inhibitory control (7 items; e.g., “I can easily resist talking out of turn, even when I'm excited and want to express an idea.”), and attention control (5 items; e.g., “When interrupted or distracted, I usually can easily shift my attention back to whatever I was doing before.”). Each item was rated on a 7-point Likert scale to indicate how well the statement described the respondent (from 1 “extremely untrue” to 7 “extremely true”). Each subscale yielded an average score across items, and the subscale scores were then averaged to represent mothers’ effortful control. For the participating mothers, Cronbach’s αs ranged from .58 to .76 for the three subscales and was .78 across all 19 items under the effortful control factor. Of a possible range of 1 to 7, the scores of effortful control ranged from 2.37 to 6.44 (M = 4.61, SD = 0.73) among participating mothers in the current sample, reflecting variability in this temperamental aspect of self-regulation.

Table **2-1**: Descriptive Statistics and Bivariate Correlations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Mother age (years)	-														
2. Child age (months)	.16*	-													
3. Child gender	.05	.06	-												
4. Challenging child behaviors	-.09	-.30***	.17*	-											
5. Maternal negative emotions	.01	-.11	.07	.44***	-										
6. Reappraisal	.07	.04	.08	-.01	.20*	-									
7. Distraction	.03	-.04	.02	-.07	.10	.62***	-								
8. Suppression	-.03	-.16*	.06	.03	.30***	.46***	.43***	-							
9. Rumination	-.03	-.02	.03	.07	.28***	.25**	.29***	.29***	-						
10. Resting RSA	-.19*	.02	.07	-.07	-.07	.15	.06	-.02	.00	-					
11. Task RSA	-.24**	-.06	.05	-.02	-.07	.13	.08	-.04	-.02	.86***	-				
12. RSA reactivity	-.07	-.14	-.05	.10	.02	-.06	.03	-.02	-.04	-.41***	.13	-			
13. Maternal responsiveness	-.04	-.33***	.26**	.54***	.22**	.08	-.02	.03	.06	.09	.14	.07	-		
14. ER difficulties	-.08	-.12	.05	.29***	.28***	-.08	-.08	.11	.34***	-.13	-.15	-.01	.14	-	
15. Effortful control	-.02	.04	.07	-.17*	-.02	.11	.11	.16*	-.11	.02	.07	.09	-.11	-.38***	-
M	35.19	45.08	0.50	0.59	1.30	5.24	5.74	4.09	3.54	5.68	5.32	-0.36	0.39	2.03	4.61
SD	5.10	8.17	0.50	0.47	1.25	2.51	2.23	2.55	2.42	1.24	1.15	0.65	0.31	0.50	0.74

Notes. Child gender was coded as 0 for female and 1 for male. Positive RSA reactivity represented an increase in RSA during the Wait Task compared to the resting baseline, whereas negative RSA reactivity represented a decrease in RSA. ER difficulties = Mothers' trait-like emotion regulation difficulties. $^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$.

Data analysis and results

Given the focus on inter-individual differences in mothers' emotions, physiology, strategies, and behaviors, the current study tested hypotheses through correlations and multiple regression models fit to data of 157 mothers. All predictors in the regression models were centered around sample means, and the interaction terms were created using the centered variables. Data preparation and analyses were conducted in R (R Core Team, 2016). Statistical significance was evaluated with $\alpha = .05$. Descriptive statistics and bivariate correlations are presented in Table 2-1.

Aim 1: Associations among multiple indicators of maternal emotional responses and observed maternal responsiveness

As shown in Table 2-1, mothers' self-reported negative emotions were not significantly correlated with their resting RSA ($r = -.07$, $p = .36$) or average RSA reactivity ($r = .02$, $p = .81$) during the Wait Task, suggesting that when summarized across the task, mothers' subjective experience of negative emotions and physiological reactivity were not aligned with one another. Bivariate correlations indicated that mothers whose children were more challenging during the Wait Task reported experiencing more negative emotions ($r = .44$, $p < .01$) but demonstrated higher levels of responsiveness ($r = .54$, $p < .01$), with the latter two variables also positively correlated ($r = .22$, $p < .01$). However, mothers' resting RSA or average RSA reactivity was not significantly correlated with how challenging their children were or the average level of maternal responsiveness during the Wait Task (see Table 2-1).

Results of the multiple regression model testing Hypotheses 1a and 1b are presented in Table 2-2. Hypothesis 1a about the main effects of subjective emotions and RSA measures was not fully supported by the data. After controlling for the average level of challengingness in children's behaviors during the task, mothers' subjective negative emotions were not associated with their responsiveness ($b = 0.002$, $p = .89$). Thus, the bivariate correlation between mothers' subjective negative emotions and responsiveness was likely explained by how challenging their children were during the Wait Task (i.e., challenging child behaviors may invoke mothers' negative emotions while also demanding more attention and support from mothers). Regarding the RSA measures, consistent with prediction, resting RSA had a significant main effect, such that higher resting RSA was related to higher levels of maternal responsiveness ($b = 0.05$, $p = .01$). Mothers' average RSA reactivity during the Wait Task, although correlated with their resting RSA ($r = -.41$, $p < .01$; mothers with higher resting RSA showed a greater decrease in RSA during the task), was not associated with maternal responsiveness ($b = 0.04$, $p = .19$).

Hypothesis 1b regarding the interaction between subjective emotions and RSA measures was only partially supported. Consistent with the hypothesis, there was a significant interaction between mothers' subjective negative emotions and resting RSA in predicting maternal responsiveness ($b = 0.05$, $p < .01$). As shown in Figure 2-3, more negative emotions were associated with higher levels of responsiveness among mothers with higher resting RSA (the simple slope of negative emotions was positive when resting RSA was at 1 standard deviation below the sample mean, coefficient = 0.06, $p = .03$), but were associated with lower levels of responsiveness among mothers with lower resting RSA (the simple slope was negative when resting RSA was at 1 standard deviation below the sample mean, coefficient = -0.05, $p = .02$). In contrast, the interaction between mothers' RSA reactivity and subjective negative emotions was

not statistically significant (b = -0.02, p = .58), suggesting that mothers' RSA reactivity did not moderate the relation between subjective negative emotions and responsiveness.

Table **2-2**: Maternal Negative Emotions and RSA Measures Predicting Maternal Responsiveness

Predictor	Maternal Responsiveness	
	b (*SE*)	*p*
Intercept	**0.39** (0.02)	< .01
Child age	**-0.01** (0.003)	< .01
Child gender	**0.13** (0.04)	< .01
Challenging child behaviors	**0.29** (0.05)	< .01
Maternal NE	0.002 (0.02)	.89
Resting RSA	**0.05** (0.02)	.01
Maternal NE × Resting RSA	**0.05** (0.01)	< .01
RSA reactivity	0.04 (0.03)	.19
Maternal NE × RSA reactivity	-0.02 (0.03)	.58
F (df1, df2)		13.46 (8, 144)
p		< .01
Adjusted R^2		.40

Notes. Child gender was coded as 0 for female and 1 for male. NE = Subjective negative emotions. All predictors were centered around sample means. Statistically significant coefficients were bolded.

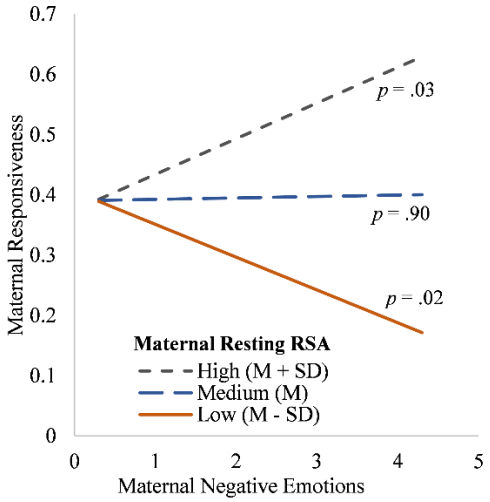

Figure **2-3**: The association between mothers' subjective negative emotions and observed responsiveness was moderated by maternal resting RSA.

Aim 2: Mothers' strategy-use when experiencing negative emotions

Bivariate correlations (see Table 2-1) suggested that mothers' subjective experience of negative emotions was positively correlated with their use of reappraisal (r = .20, p = .01), suppression (r = .30, p < .01), and rumination (r = .28, p < .01), but not with the use of distraction (r = .10, p = .21). That is, in support of Hypothesis 2a, mothers who reported experiencing more negative emotions also attempted to reappraise the situation, suppress their emotions, and think over their emotions more. Additionally, strategy use among the four types were all positively correlated with each other (rs = .25 - .62, ps < .01). In other words, it was not the case that mothers who used the presumably adaptive strategies more (reappraisal and distraction) would use the presumably maladaptive strategies less (suppression and rumination), or vice versa. Rather, these results suggested that when mothers experienced more negative emotions about their children's behaviors, they invoked a range of strategies in an attempt to manage these emotions. The average level of challenging child behaviors and maternal responsiveness were not significantly correlated with mothers' strategy-use. However, there was a significant correlation between child age (but not maternal age) and mothers' use of suppression (r = -.16, p = .04), such that mothers of younger children attempted to suppress their own negative emotions more during the Wait Task.

Next, I examined whether and how mothers' trait-like emotion regulation difficulties and effortful control were associated with their use of strategies during the Wait Task. Bivariate correlations indicated that both measures of mothers' trait-like self-regulation were related to how challenging their children were during the Wait Task. Children of mothers who reported more emotion regulation difficulties (r = .29, p < .01) or lower effortful control (r = -.17, p = .04) showed a higher average level of observed challenging behaviors. Trait-like emotion regulation

difficulties (r = .28, p < .01), but not effortful control (r = -.02, p = .81), was also correlated with mothers' subjective negative emotions during the Wait Task. However, neither of the two trait-like measures was significantly correlated with maternal responsiveness (r = .14, p = .09 for emotion regulation difficulties; r = -.11, p = .17 for effortful control). Regarding strategy-use, mothers' trait-like emotion regulation difficulties were significantly correlated with more rumination (r = .34, p < .01) but not the other strategies (rs = -.08 - .11, ps > .05). Meanwhile, better effortful control was correlated with more suppression (r = .16, p = .04) but not the other strategies (rs = -.11 - .11, ps > .05).

Four regression models were then used to test Hypothesis 2b, with the trait-like measures of self-regulation entered together with covariates to predict mothers' use of each of the four strategies during the Wait Task. Mothers' subjective negative emotions were controlled for in all four models, as the extent to which mothers invoked regulatory strategies was dependent on the amount of negative emotions they experienced in the situational context. Child age was also included as a covariate in the model predicting suppression given the correlation between them. Overall, results provided minimal support for Hypothesis 2b. As shown in Table 2-3, after accounting for the effect of mothers' subjective negative emotions, mothers' trait-like emotion regulation difficulties and effortful control were not associated with mothers' use of reappraisal or distraction. In the model predicting mothers' use of suppression, effortful control, but not emotion regulation difficulties, had a significant effect. However, contrary to the hypothesis, mothers with better effortful control actually reported suppressing their negative emotions more in this challenging parenting situation (b = 0.74, p = .01). Lastly, the results of the model predicting mothers' use of rumination were partially consistent with the hypothesis. Although there was not a significant effect of effortful control (b = 0.002, p = .99), mothers with greater trait-like emotion regulation difficulties tended to ruminate over their negative emotions more (b = 1.44, p < .01).

Table **2-3**: Trait-Like Emotion Regulation Difficulties and Effortful Control Predicting Strategy-Use

Predictor	Reappraisal		Distraction		Suppression		Rumination	
	b (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*	*b* (*SE*)	*p*
Intercept	**5.27** (0.20)	< .01	**5.76** (0.18)	< .01	**4.10** (0.19)	< .01	**3.55** (0.18)	< .01
Child age	-		-		-0.04 (0.02)	< .01	-	
Maternal NE	**0.50** (0.16)	< .01	0.24 (0.15)	.11	**0.55** (0.16)	< .01	**0.40** (0.15)	< .01
ER difficulties	-0.45 (0.45)	.31	-0.28 (0.41)	.50	0.57 (0.44)	.20	**1.44** (0.41)	.01
Effortful control	0.28 (0.29)	.34	0.28 (0.26)	.29	**0.74** (0.28)	.01	0.002 (0.27)	.99
F (df1, df2)	3.73 (3, 152)		1.57 (3, 152)		6.60 (4, 151)		9.56 (3, 152)	
p	.01		.20		< .01		< .01	
Adjusted R^2	.05		.01		.13		.14	

Notes. NE = Subjective negative emotions. ER difficulties = Emotion regulation difficulties. All predictors were centered around sample means. Statistically significant coefficients were bolded.

Aim 3: The moderating role of strategies in the relation between emotional indicators and maternal responsiveness

The last aim examined whether and how mothers' strategy-use moderated (a) the relation between their subjective negative emotions and responsiveness to child, and (b) the relation between their RSA reactivity and responsiveness to child. Accordingly, two multiple linear regression models were examined. In Model 3a, mothers' subjective negative emotions, regulatory strategies, and the interactions between them were entered as predictors of maternal responsiveness. In Model 3b, mothers' RSA reactivity, regulatory strategies, and their interaction were entered as predictors of maternal responsiveness. Child age, gender, and challenging behaviors were entered as covariates for both models; mothers' resting RSA was also entered as a covariate in Model 3b. Given the relatively large number of predictors and the moderate sample size, I applied a backward elimination process to select the predictors to be included in the final parsimonious models. Starting from a full model with all predictors included (see Model 3a Full and Model 3b Full in Tables 2-4 and 2-5), at each step, I removed one strategy and its interaction term (e.g., *Distraction* and *Maternal NE* × *Distraction*) and compared the models before and after the removal. If model comparison suggested that the strategy and the interaction term did not

contribute significantly to model fit (evaluated at $\alpha = .05$), they were not included in the final model.

Results of the final models are presented in Table 2-4 and Table 2-5 (see Model 3a Final and Model 3b Final). Hypothesis 3 was only partially supported. In Model 3a, there was only a significant interaction of suppression ($b = -0.02$, $p = .03$), but not the other three strategies, with mothers' negative emotions in predicting maternal responsiveness. I probed the interaction by estimating the simple slopes of subjective negative emotions at different levels of suppression. As shown in Figure 2-4, for mothers who used suppression less (1 SD below mean), there was a positive association between mothers' negative emotions and maternal responsiveness, although the coefficient of the simple slope did not reach statistical significance (coefficient of simple slope = 0.06, $p = .07$). For mothers who used suppression at an average or higher level (mean or 1 SD above mean), their subjective negative emotions were not associated with the level of responsiveness across the task (coefficients of simple slope = -0.02–0.02, ps > .30). Overall, this suggested that mothers who did not attempt to suppress their emotions were more likely to attend to children's needs in a responsive way even when they experienced negative emotions.

In Model 3b, similar findings emerged such that only suppression, among the four regulatory strategies, had a significant interaction with RSA reactivity in predicting maternal responsiveness ($b = -0.03$, $p = .03$). As shown in Figure 2-5, for mothers who suppressed emotions less (1 SD below mean), higher levels of RSA reactivity (i.e., an increase in RSA during the Wait Task compared to baseline) were associated with higher levels of maternal responsiveness (coefficient of simple slope = 0.11, $p = .03$). There were no significant associations between mothers' RSA reactivity and maternal responsiveness among those with an average or higher level (mean or 1 SD above mean) of suppression (coefficients of simple slope = -0.03–0.04, ps > .20). Note that although suppression interacted with both subjective negative emotions (Model 3a) and RSA reactivity (Model 3b) in predicting maternal responsiveness,

mothers' subjective negative emotions and RSA reactivity were not correlated with each other.

Therefore, the moderation effects in the two models should be interpreted independently.

Table **2-4**: Strategies Moderating the Association Between Maternal Negative Emotions and Maternal Responsiveness

Predictor	Maternal Responsiveness Model 3a Full *b* (*SE*)	*p*	Maternal Responsiveness Model 3a Final *b* (*SE*)	*p*
Intercept	**0.40** (0.02)	< .01	**0.40** (0.02)	< .01
Child age	**-0.01** (0.003)	< .01	**-0.01** (0.003)	< .01
Child gender	**0.12** (0.04)	< .01	**0.12** (0.04)	< .01
Challenging child behaviors	**0.27** (0.05)	< .01	**0.27** (0.05)	< .01
Maternal NE	0.01 (0.02)	.59	0.02 (0.02)	.32
Reappraisal	0.02 (0.01)	.11	-	
Maternal NE × Reappraisal	0.01 (0.01)	.16	-	
Distraction	-0.01 (0.01)	.60	-	
Maternal NE × Distraction	0.002 (0.02)	.89	-	
Suppression	-0.01 (0.01)	.31	-0.01 (0.01)	.31
Maternal NE × Suppression	**-0.02** (0.01)	.03	**-0.02** (0.01)	.03
Rumination	0.002 (0.01)	.83	-	
Maternal NE × Rumination	0.001 (0.01)	.89	-	
F (df1, df2)	7.78 (12, 141)		14.79 (6, 147)	
p	< .01		< .01	
Adjusted R^2	.35		.35	

Notes. Child gender was coded as 0 for female and 1 for male. NE = Subjective negative emotions. All predictors were centered around sample means. Statistically significant coefficients were bolded.

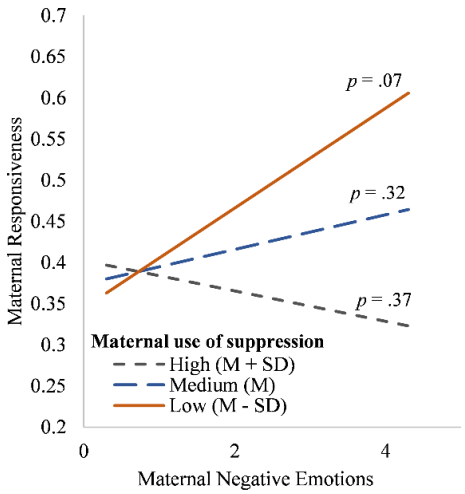

Figure **2-4**: Mothers' use of suppression moderated the relation between their subjective negative emotions and responsiveness to their children.

Table **2-5**: Strategies Moderating the Association Between RSA reactivity and Maternal Responsiveness

Predictor	Maternal Responsiveness Model 3b Full *b*(*SE*)	*p*	Maternal Responsiveness Model 3b Final *b*(*SE*)	*p*
Intercept	**0.40** (0.02)	< .01	**0.39** (0.02)	< .01
Child age	**-0.01** (0.003)	< .01	**-0.01** (0.003)	.01
Child gender	**0.12** (0.04)	.01	**0.11** (0.04)	.01
Challenging child behaviors	**0.30** (0.05)	< .01	**0.30** (0.05)	< .01
Resting RSA	**0.04** (0.02)	.03	**0.04** (0.02)	.03
RSA reactivity	0.05 (0.04)	.13	0.04 (0.03)	.21
Reappraisal	0.02 (0.01)	.06	-	
RSA reactivity × Reappraisal	-0.01 (0.02)	.51	-	
Distraction	-0.01 (0.01)	.27	-	
RSA reactivity × Distraction	0.03 (0.02)	.19	-	
Suppression	-0.01 (0.01)	.30	-0.01 (0.01)	.52
RSA reactivity × Suppression	**-0.03** (0.01)	.03	**-0.03** (0.01)	.03
Rumination	0.004 (0.01)	.67	-	
RSA reactivity × Rumination	-0.01 (0.01)	.38	-	
F (df1, df2)	7.58 (13, 139)		13.35 (7, 145)	
p	< .01		< .01	
Adjusted R^2	.36		.36	

Notes. Child gender was coded as 0 for female and 1 for male. NE = Subjective negative emotions. All predictors were centered around sample means. Statistically significant coefficients were bolded.

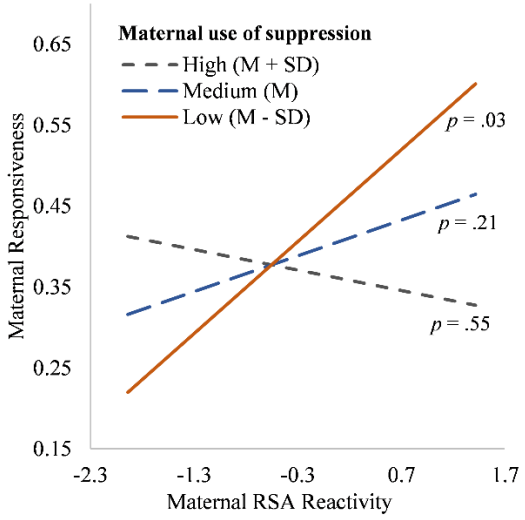

Figure **2-5**: Mothers' use of suppression moderated the relation between their RSA reactivity and responsiveness to their children.

Discussion

The findings of this study characterize mothers' use of strategies to manage negative emotions in a challenging parenting situation, and reveal how specific strategies may moderate the relations between indicators of emotional phenomena and mothers' responsiveness to their children. In this community sample of mothers, results suggested that mothers' subjective experience or physiological manifestation of emotions were not determinants of maternal responsiveness when interacting with their 30- to 60-month-old children. Rather, their relations were moderated by factors including mothers' basal parasympathetic functioning (i.e., resting RSA) and attempts to suppress their own negative emotions. Together, these findings indicate the value of examining variations in the relationship between parents' emotional indicators and parenting behaviors as a potential way to infer inter-individual differences in parental emotion regulation.

Emotional indicators and maternal responsiveness

The current study examined multiple indicators of emotional phenomena, including mothers' subjective experience and physiological reactivity, which represent different components of emotion that may have unique implications for parenting behaviors. Contrary to the hypothesis that subjective negative emotions would make it harder for mothers to attend and tailor behaviors to their children's needs (Lorber & O'Leary, 2005; Martin et al., 2002), more subjective negative emotions were actually correlated with higher levels of responsiveness among mothers in this sample. This correlation was likely explained by how challenging their children were during the task, as these challenging behaviors could evoke mothers' negative emotions and also demand efforts from parents to soothe their children and help them regulate. After

controlling for how challenging their children were in the regression analysis, mothers who reported experiencing higher versus lower levels of negative emotions showed comparable levels of responsiveness to their children.

This finding resembles a pattern identified in a previous study (Hajal et al., 2019), in which mothers reported relatively high levels of negative emotions and desire to disengage with the situation, but managed to stay engaged to attend to their children. This pattern, which characterized a quarter of the parenting situations examined in that study, was interpreted as reflecting the effect of mothers' emotion regulation (i.e., selecting alternative actions rather than acting upon prepotent desires). It is worth noting that the pattern identified in Hajal et al. (2019) was further characterized by higher levels of worry or concern compared to situations where mothers simply disengaged when they desired to do so. Although the current study did not examine the inter-individual differences in discrete emotions (due to their occurrence and the limited variability in individual emotions), mothers in this sample did report more worry-related emotions (i.e., tense, nervous, anxious) relative to other negative emotions (see Figure 2-2). This similarity points to the possibility that mothers' worry and concern at the conscious level may play a role in the regulation of parenting behaviors, which warrants further examination. Similar to findings in previous studies (Augustine & Leerkes, 2019; Lorber & O'Leary, 2005), no relations were found between mothers' task-average RSA reactivity and their self-reported negative emotions. Such lack of concordance among multiple components of emotion has been widely documented (Hollenstein & Lanteigne, 2014), and is consistent with the notion that individuals' physiological reactivity reflects their action readiness that is potentially unconscious and distinct from subjective experience. As parasympathetically-mediated physiological arousal is often presumed to be an adaptive way to respond to emotionally challenging situations (Porges, 2007), I further examined whether mothers' RSA reactivity and subjective emotions jointly predicted maternal responsiveness. However, results suggested that the task-average RSA

reactivity did not show a main effect, nor did it interact with mothers' subjective negative emotions in predicting maternal responsiveness. Again, these null findings may reflect the effect of regulation; that is, mothers may have engaged in cognitive processes to alter prepotent readiness to act. Meanwhile, the null findings may also be due to the limitations of an aggregated approach. A parenting task usually encompasses numerous behavioral exchanges and ebbs and flows of emotions (Lorber & Slep, 2005; Lunkenheimer, Albrecht, & Kemp, 2013; Scholtes, Lyons, & Skowron, 2020) driven by ongoing activation and regulation processes. Therefore, when mothers summarize their subjective emotional experiences across the task, or when their average RSA across the task is used to calculate RSA reactivity, the resultant measures may mask the underlying emotional dynamics and obscure their associations with parenting behaviors. Therefore, a dynamic approach that examines the moment-to-moment changes in parents' subjective experience (e.g., Lorber & Slep, 2005) and/or parasympathetic activity may be necessary to further our understanding of the emotional underpinnings of parenting behaviors.

Moderators of the relation between emotional indicators and maternal responsiveness

The findings of the current study further identified factors that moderated the relation between mothers' subjective negative emotions or RSA reactivity and maternal responsiveness. These factors, including mothers' basal parasympathetic functioning (indicated by resting RSA) and strategy-use, reflect potential mechanisms that explain the inter-individual differences in mothers' emotion regulation in this specific parenting context.

Maternal resting RSA

Previous theoretical and empirical work has suggested that individuals with higher resting RSA may have greater cognitive resources available for regulatory attempts (Thayer & Lane, 2009; Williams, Thayer, & Koenig, 2016). Higher resting RSA among mothers has also been linked to more sensitive parenting behaviors (Joosen et al., 2013; Musser et al., 2012). Consistent with previous work, in the current sample, higher resting RSA had a main effect in predicting higher levels of maternal responsiveness, and also moderated the relation between mothers' subjective negative emotions and maternal responsiveness. Mothers with higher resting RSA managed to be even more responsive to their children if they experienced negative emotions about how their children were handling the wait, which may reflect their effort to address the challenge in a child-centered manner. In contrast, mothers with lower resting RSA became less responsive if they experienced negative emotions, which may reflect lower regulatory capacity to support responsive behaviors. Interestingly, mothers' resting RSA was not correlated with their use of specific strategies measured in this study or trait-like effortful control and emotion regulation difficulties. Future research could continue to explore other cognitive and neurophysiological mechanisms through which parents' resting RSA may be related to their self-regulation in the moment of parenting.

Maternal strategy-use

In the current sample, mothers who experienced negative emotions during the Wait Task invoked a range of strategies (see Figure 2-2). Among previous studies with parents or non-parent adults, the use of presumably adaptive strategies (e.g., reappraisal) often had little overlap with the use of presumably maladaptive strategies (e.g., suppression; Lorber, 2012; Moore,

Zoellner, & Mollenholt, 2008; Preece, Becerra, Robinson, & Gross, 2020). This was not the case in this sample; mothers' self-report ratings on the four strategies were all positively correlated, and more negative emotions were correlated with more use of reappraisal, suppression, and rumination. That is, mothers tended to engage in a variety of strategies across the duration of this challenging parenting situation.

In the models of adult emotion regulation, modifying the attention to or perception of the emotionally-provoking situation (i.e., distraction or appraisal) is typically seen as effective in reducing negative emotional experiences and expressive behaviors (Efinger et al., 2019; Gross, 2002). One study also found that mothers' reappraisal in discipline encounters was related to less harsh parenting behaviors (Lorber, 2012). However, in the current sample, mothers' use of these two presumably adaptive strategies was not associated with their trait-like effortful control or emotion regulation difficulties, nor did they have any main effect or interact with the emotional indicators in predicting maternal responsiveness. One possible explanation is that the extent to which parents invoke a strategy does not necessarily reflect whether and how this strategy takes effect in specific parenting situations that posit unique demands. Moreover, parents' cognitive modification processes may not always emerge to their conscious awareness, which can make it hard for them to accurately report it. To summarize, although there was evidence for the existence of regulatory process among mothers in this sample (i.e., they reported experiencing more negative emotions but showed higher levels of responsiveness when their children were challenging), mothers' self-report of the two common cognitive strategies did not explain inter-individual differences in the regulation.

The analyses regarding maternal suppression – a strategy that may be ineffective in reducing one's own negative feelings (Goldin et al., 2008) but functional in interpersonal contexts (English et al., 2017), yielded interesting findings. Contrary to the hypothesis, mothers with better effortful control reported suppressing their negative emotions more during the Wait Task.

In other words, mothers who were better capable of voluntarily modulating their attention and behaviors engaged in a greater effort to push down or conceal their negative emotions. Although their intention might be to not act on these negative feelings when interacting with their children, suppression did not seem to support maternal responsiveness. Consistent with previous research (Le & Impett, 2016; Waters et al., 2020), mothers were less responsive when they experienced negative emotions but tried to suppress them. Moreover, an increase in maternal RSA during the Wait Task (relative to the baseline) was associated with higher levels of responsiveness only among mothers who did not engage in suppression much. It is possible that in the context of the Wait Task, where there were fewer opportunities for interaction compared to typical dyadic tasks (e.g., solving a puzzle together), maintaining an overall higher level of parasympathetic activity helped mothers attend and tailor behaviors to their children's needs, but only when they did not try to suppress their negative feelings.

Lastly, as expected, mothers with more trait-like emotion regulation difficulties engaged in rumination more during the Wait Task. Rumination might have enhanced mothers' negative feelings, but this conclusion could not be drawn with the current analyses without examining the dynamic changes in maternal emotions. Despite being widely regarded as an ineffective and maladaptive strategy (Aldao et al., 2010; Moberly & Watkins, 2008), rumination was not related to maternal responsiveness or moderate the relations between mothers' emotional indicators and responsiveness.

Collectively, these findings suggest that parents' use of strategies to manage emotions may be highly context-specific and not necessarily related to trait-like measures of self-regulation unrelated to the context of parenting. Although there was some evidence that mothers likely engaged in regulation to maintain or increase their responsiveness to their children even if they experienced negative emotions about children's behaviors, only one of the four self-reported

strategies (i.e., suppression) was related to the inter-individual differences in such regulatory effects.

Limitations and future directions

The current study has several limitations that require caution in the interpretation of findings and warrant further investigation in future studies. First, as discussed above, the aggregated approach (i.e., examining the average levels of maternal physiology and behaviors, and asking mothers to summarize their emotional experience and strategy-use across the entire task) masks how the regulation processes may unfold on a moment-to-moment basis. For example, parents may feel upset about their children's behaviors or experience an increase in physiological arousal, but soon engaged in a strategy that effectively calms themselves down and enables them to respond sensitively to their children. It is thus not clear whether (or the extent to which) the current measures of maternal subjective emotions and average RSA reactivity reflected activated emotional responses and/or the effects of ensuing regulatory processes. To address this lack of clarity, Study 2 (see Chapter 3) adopts a dynamic systems approach to investigate the interplay between mothers' moment-to-moment physiology and behaviors in the context of children's challenging behaviors.

Second, the current study only measured a limited range of strategies. In the moment of parenting, parents may engage in a wide variety of cognitive processes that do not necessarily fit into the categories of strategies commonly examined in the literature of adult emotion regulation. These processes may vary across individuals, contexts, or even from moment to moment. Therefore, it can be difficult to capture them directly through the current questionnaire. To further our understanding of how parents self-regulate in challenging parenting situations, qualitative inquiries with open-ended interviews may be helpful. Another potential way to infer

the effects of cognitive processes is to examine the dynamic changes and dynamic relations of parents' emotional indicators and behaviors, which is addressed in the next chapter. It should also be noted that only 2 items were used to measure each strategy. Therefore, the findings should be interpreted with caution.

Finally, the findings with this relatively homogenous community sample may not represent patterns in families from more diverse backgrounds. For example, the family's cultural background may influence parents' choice of strategies in challenging parenting situations as well as the effectiveness of these strategies, which would be a promising direction for future work. Furthermore, mothers in the current sample only reported low levels of negative emotions during the Wait Task. In a higher-risk sample or during more emotionally provoking situations, a different pattern of strategy-use and parental emotion regulation may emerge.

Conclusions

In summary, the current study suggests that mothers' subjective experience of negative emotions is not deterministically associated with lower levels of maternal responsiveness. On the contrary, mothers may be able to maintain or even increase the level of responsiveness when they experience negative emotions, potentially reflecting the effect of regulatory processes. Furthermore, mothers' basal parasympathetic functioning (i.e., higher resting RSA) may contribute to their regulation, whereas attempts to suppress negative emotions may impede their regulation. Together, these findings support the notion that negative emotions in challenging parenting situations are not necessarily problematic, but how parents regulate them may influence their parenting behaviors (Cole, 2016). In other words, parenting competence is not necessarily about not having negative feelings in the challenging moments of parenting, but rather about not getting derailed by these emotions. Prevention and intervention efforts aiming to improve

parental responsiveness can help parents be mindful of their negative feelings without trying to simply suppress them, and promote child-centered ways to address parenting challenges.

Chapter 3

A Dynamic Systems Account of Maternal Emotion Regulation Processes: Time-Series Analysis of Mothers' Physiology and Behaviors

Introduction

As discussed in the first two chapters, the relation between parents' negative emotions and behavioral responsiveness to their child, that is, showing higher levels of responsiveness despite experiencing negative emotions, could be an important manifestation of parental emotion regulation. However, the aggregated approach adopted in Study 1 does not address how regulatory processes unfold in the moment of parenting to continuously shape their parental emotions and parenting behaviors. Emotions, including one's appraisal and readiness to act, evolve constantly with the changing circumstances (Scherer, 2009). Arguably, the regulation of emotions is also an ongoing process that influences one's internal emotional states (e.g., subjective experience, psychophysiological response) as well as whether and how they translate into actual behavioral reactions on a moment-to-moment basis (Carver & Scheier, 2011; Cole et al., 2019). Understanding the processes of parental emotion regulation is critical for identifying the timing (e.g., the moments when the level of responsiveness drops) and mechanisms (e.g., how parents manage to or fail to maintain the level of responsiveness) that could be targeted to improve the quality of parenting.

In the past decade, researchers have called for utilizing the rich information embedded in time-series data, that is, the moment-to-moment dynamics of parents' emotions and behaviors, to understand their regulatory processes (Morris, Cui, Criss, & Simmons, 2018; Teti & Cole, 2011). However, there has not been a consistent conceptual model of emotion regulation that accommodates the specificity of the parenting context to help integrate the growing empirical efforts. In the moment of parenting, parental emotion regulation needs to serve two important

purposes – maintaining internal emotional equilibrium (e.g., avoiding excessive and/or prolonged physiological arousal) that supports parents' own well-being, and responding to their children's needs to support their well-being. These two purposes are not independent of each other; for instance, the disturbance to parents' emotional equilibrium is functionally associated with readiness for action that may influence how parents respond behaviorally to their children. Meanwhile, these two purposes do not completely overlap; evidence suggests that parents' internal emotional processes often do not align with how they act, and the discrepancy itself could indicate regulatory effects (Hajal et al., 2019; also see Study 1). The processes involved in balancing these two purposes are not addressed in general models of adult emotion regulation, and could not be captured by aggregated or summarized measures of parental emotions or behaviors. Adopting a dynamic systems approach, the current paper provides a conceptual model of parental emotion regulation that aims to address these complex processes. Furthermore, the model is tested using time-series data of mothers' physiological activity and behavioral responsiveness to their child in a challenging parenting situation.

A dynamic systems approach to the study of parental emotion regulation

Recent conceptual work has defined emotion regulation as engaging higher-order cognitive processes to alter prepotent emotional reactions (Cole et al., 2019; Nigg, 2017). However, a major challenge in examining this construct is that the actual processes of regulation are hard to measure directly. For instance, parents may invoke a diverse set of cognitive processes to manage their emotions and behaviors (e.g., re-prioritize goals, shifting attention, etc.). Those cognitive processes are largely internalized and not always conscious, and may vary across individuals, contexts, or even from moment to moment. It is thus difficult to directly assess them (e.g., through self-report or observational measures) or the extent to which they

actually influence parents' emotions and behaviors. What can be directly measured, however, is how the manifested emotions and behaviors change dynamically over time. From a dynamic systems perspective, these seemingly complex and disorderly dynamics are the key to extracting patterns of regularity that reflect the underlying processes of regulation.

A dynamic system is defined as a collection of elements that interact constantly to support the system's functioning as a whole (Kelso, 1995). How these interacting elements evolve over time is organized by a set of rules that govern the intrinsic dynamics of individual elements and the way they coordinate with each other. Therefore, a dynamic systems approach includes conceptual and mathematical accounts of time-structured intra-individual variability and the underlying *dynamic processes* – the organizing rules reflected in patterns of regularity (Ram & Gerstorf, 2009). This approach is useful in the study of human experience because an individual is essentially a complex system, with billions of basic elements (e.g., neurons, neurotransmitters, muscles) coordinated to serve various functions (e.g., breathing, speaking, walking; Kelso, 1995; Vallacher, Read, & Nowak, 2002).

When applied specifically to the study of parental emotion regulation, the elements of interest are not individual neurons or muscles, but the components of parents' emotions and behaviors that are most relevant to the context of parenting. As discussed earlier, a model of emotion regulation that accommodates the parental role needs to account for how the two prominent purposes – maintaining parents' internal emotional equilibrium and responding to their children's needs – are balanced in the challenging moments of parenting. Therefore, I consider each parent as a dynamic system, in which the coordination between two key elements enables the parent to adapt to both internal and external demands. The two elements of interest are (1) parents' parasympathetically-mediated physiological activity (measured by respiratory sinus arrhythmia; RSA), which is functionally associated with the maintenance of homeostatic body functioning as well as the preparation for action in emotionally challenging situations, and (2) the

level of responsiveness in how parents act toward their child. I propose that how these elements evolve and interact with each other over time reflects the core *dynamic processes* of parental emotion regulation in the context of challenging child behaviors.

The dynamic processes of parental emotion regulation

Taking a systems view, the equilibrium of a system refers to a state where elements are at their set points or free of perturbation. In the case of parental emotion regulation, children's behaviors that are challenging to parents (i.e., those that interfere with parents' other tasks or conflict with parents' expectations) can be considered as external sources of perturbation. Although emotion regulation is an ongoing process, for the ease of interpretation, we could view the perturbations to the system as the start points, or "triggers", of ensuing regulatory processes. Conceptual accounts of self-regulation have suggested that in a well-regulated system, that is, a system that can form organized responses and restore equilibrium after being perturbed, how its elements evolve and interact over time is commonly characterized by negative feedback loops (Carver & Scheier, 2008; Gross, 2015; Hollenstein, 2015; Lewis, 2000). Accordingly, I hypothesize that the dynamic processes underlying a well-regulated parent (i.e., a parent who can be responsive to the child and also restore internal emotional equilibrium after being perturbed by challenging child behaviors) can be conceptualized as (see Figure 3-1):

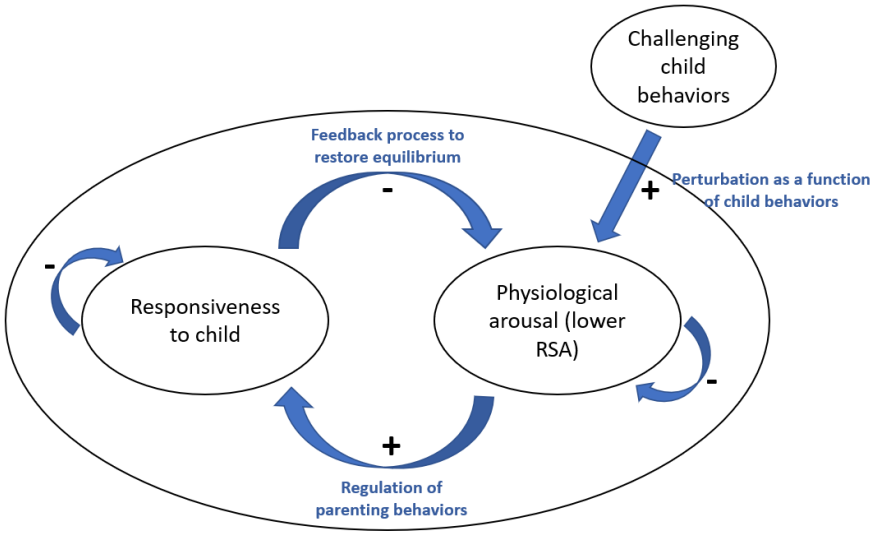

Figure **3-1**: Hypothesized dynamic processes of parental emotion regulation.

In brief, children's behaviors that are challenging to parents would perturb the system from equilibrium, e.g., reflected in an increase in parents' physiological arousal or subjective experience of negative emotions (if the perturbation emerges to conscious awareness). For a well-regulated parent, the perturbation would give rise to more responsive parenting behaviors. That is, the parent would manage to respond sensitively despite being challenged. Meanwhile, higher levels of parental responsiveness would in turn facilitate the restoration of the parent's internal emotional equilibrium. In other words, as the parent acknowledges and tailors parenting behaviors to the child's needs, the perturbation to the parent's emotional equilibrium would also start to dissipate. Additional processes may also be involved that govern the elements' intrinsic dynamics (e.g., an intrinsic force for one's physiological activity to return to set points). However, in the current paper, I focus on the three dynamic processes that reflect how the system is perturbed and how its elements interact to adapt to both internal and external demands. In the sections below, I describe each of these core processes in detail and discuss their theoretical and empirical basis.

Perturbation as a function of child behaviors

Although the term *perturbation* seems to suggest that it is disruptive to the system's optimal functioning, it is an essential part of how the system can respond and adapt to challenges. With a functional account of emotion, perturbations from emotional equilibrium arise with the appraisal that the circumstance deviates from ones' goals or ideals (Frijda, 1988). In a model of parental emotion regulation, we are most interested in perturbations – reflected by changes in parents' internal emotional states – as a function of their children's behaviors. To capture such changes in empirical research, measuring physiological indices of parents' emotions can be particularly helpful. Physiological measures can be collected continuously and unobtrusively in the moment of parenting, providing access to the rapid and sometimes unconscious process of how an individual is preparing to engage with the circumstance. I argue that parents' parasympathetic activity is a particularly relevant indicator of the extent of perturbation from their internal equilibrium. The parasympathetic nervous system typically exerts constant inhibition over arousal in end organs to support rest-and-digest activities that maintain homeostatic body functioning. Meanwhile, it can quickly withdraw and reinstate the inhibitory control, enabling individuals to increase physiological arousal in response to challenges and recover in a timely manner (Porges, 1995, 2007). Therefore, it has been argued that the dynamic changes in parasympathetic activity play a primary role in individuals' responses to mildly and moderately challenging situations, especially during social interaction that demands flexible modulation of emotions and behaviors (Muhtadie, Akinola, Koslov, & Mendes, 2015; Porges, 2003).

In the current model, when children's behaviors are more challenging, parents are expected to show a withdrawal of parasympathetic control, resulting in an increase in physiological arousal that represents perturbation to their internal emotional equilibrium. Such

perturbation may be transient and quickly modulated by ensuing regulatory processes. Therefore, it would be best captured through repeated measures of parasympathetic activity on a fast time scale (e.g., second-by-second). As introduced in Chapter 2, parasympathetic activity is commonly measured by RSA, an index of heart rate variability as a function of respiration (higher RSA indicates greater parasympathetic activity; Berntson, Cacioppo, & Quigley, 1993). Although parasympathetic input can alter cardiac activity on a beat-by-beat basis (Saul, 1990; Somsen, Jennings, & Van der Molen, 2004), RSA has typically been calculated across the duration of 30 seconds or longer. Therefore, while there is evidence that parents show lower RSA when their children are distressed or act disruptively (Augustine & Leerkes, 2019; Lorber & O'Leary, 2005; Zhang et al., 2021), it is arguable that the average RSA reactivity reflects a mixture of not only the initial perturbation but also the effects of ensuing regulatory processes. To better capture the nuanced dynamics in parasympathetic activity, recent research has started to apply a moving-window technique to obtain second-by-second estimates of RSA (Gates, Gatzke-Kopp, Sandsten, & Blandon, 2015; Ravindran et al., 2019). The current study also adopts this approach in testing the model.

While Figure 3-1 characterizes the hypothesized intra-individual process of perturbation, there may be inter-individual differences in this process. The literature has characterized two patterns of perturbation processes that may have maladaptive implications for parenting. On the one hand, some researchers have argued that when exposed to challenging child behaviors, parents who are perturbed to a greater extent (e.g., greater decreases in RSA, or greater dependency of parents' negative emotions on children's challenging behaviors) may be less able to show support to their children (Lorber & Slep, 2005; Ravindran, 2019). However, as discussed earlier, it is not clear whether the measures in these studies reflected the initial perturbation or effects of the ensuing regulation, and which of them accounted for the association with parenting behaviors. On the other hand, a few studies examined repeated measures of cardiac indices

(although each measure was still calculated across 10 to 30 seconds of data) during challenging parenting situations. They found that a blunted pattern of cardiac responses, that is, parents showing little change in cardiac activity as a function of dynamically changing task demands, was related to less sensitive parenting behavior and less positive dyadic interaction (Giuliano, Skowron, & Berkman, 2015; Joosen et al., 2013; Zhang, Cui, Han, & Yan, 2017). Additionally, in some studies, such blunted responses were more common among parents with greater cardiac arousal on average (Joosen et al., 2013; Zhang et al., 2017). These findings are consistent with the notion that the perturbation process per se may not necessarily be linked with negative parenting. Rather, it may be an essential part of responding to child-related challenges, and a lack of such perturbations may be associated with constantly heightened physiological arousal (i.e., less potential for being perturbed) or not recognizing signals of children's distress, and thus interferes with parents' ability to respond sensitively.

Regulation of parenting behaviors

The functional account of emotion (Frijda, 1988; Keltner & Gross, 1999) further suggests that perturbations from emotional equilibrium motivate individuals to take actions in response. In the case of parental emotion regulation, when the source of perturbation is the child's behaviors or states, how parents choose to act in those moments of perturbation creates variation in their parenting behaviors. As discussed in Chapter 1, an important dimension of parenting behaviors that contributes to children's well-being is parental responsiveness. Compared to lashing out at the child or simply becoming disengaged, acknowledging and tailoring behaviors to the child's interests and needs typically requires more higher-order cognitive processes and effortful control (Deater-Deckard, Wang, Chen, & Bell, 2012; Harris et al., 2021). For instance, parents need to monitor and interpret children's behavioral cues to understand their needs, search for potential

ways to respond, engage reasoning to evaluate the short- and long-term consequences of potential responses, and inhibit or delay prepotent reactions to engage alternative behaviors. Therefore, if perturbation from internal equilibrium (i.e., greater parasympathetically-mediated physiological arousal, indicated by lower RSA) gives rise to higher levels of parental responsiveness, it may be inferred that some executive processes are involved to regulate parenting behaviors.

Similar to the perturbation process, the regulation of parenting behaviors is likely to unfold on a very fast time scale, and would be best captured by examining the dynamic association between parents' internal perturbations and responsiveness to their child on a moment-to-moment basis. Although no study so far has examined these nuanced dynamics, there has been preliminary evidence suggesting the existence of this regulatory process. In a recent study, Hajal and colleagues (2019) examined how intra-individual variations in mothers' subjective emotions across occasions (sampled throughout several days) predicted their momentary motivation to engage or disengage with their infant and their actual engagement or disengagement. Taking engagement behaviors for an example, this study found that on occasions when mothers reported higher levels of irritation or discouragement than their personal means (which can be considered as perturbations from equilibrium), they also reported a greater extent of not wanting to engage, but their actual engagement with the child was comparable to other occasions. In study 1 (see Chapter 2), I found similar patterns in the sample used in the current study. Specifically, mothers whose preschool-aged children were rated as more challenging by research assistants reported experiencing more negative emotions during the parenting task, but they also showed higher levels of responsiveness.

Based on findings of Study 1, the regulation of parenting behaviors among mothers in the current sample may resemble what I have described for a well-regulated parent (see Figure 3-1), that is, managing to maintain or raise their responsiveness to their child when perturbed from their emotional equilibrium. If we further examine inter-individual differences in the regulation

of parenting behaviors, it is possible that parents with certain traits (e.g., better effortful control) or who adopt more adaptive cognitive strategies (e.g., reappraisal) would show stronger regulation over their parenting behaviors (e.g., a greater increase in parental responsiveness when experiencing physiological arousal). Meanwhile, in high-risk samples, such as parents who are prone to negative parenting or even child abuse and neglect, we may observe weaker or maladaptive regulation of parenting behaviors. That is, among high-risk parents, perturbations to their internal emotional equilibrium may not lead to responsiveness to child, but rather give rise to harsh or disengaged parenting behaviors.

Feedback process to restore equilibrium

While the previous section addresses how parents fulfill the purpose of supporting their child's well-being, another important purpose of parental emotion regulation is to maintain or restore parents' own emotional equilibrium. When a system is perturbed, the restoration of equilibrium often involves negative feedback control through goal-directed actions (Carver & Scheier, 2008; Hollenstein, 2015; Powers, 1973). That is, in the context of challenging child behaviors, when parents take actions to reduce the discrepancy between concurrent circumstance and their goals or ideals, their internal states would move back toward equilibrium. There may be a variety of actions that would serve such a function, such as responding sensitively to address the child's demands, adjusting the goal (e.g., from "completing parents' own work" to "enjoy some time with the child"), or even being harsh to the child (e.g., yelling "don't bother me!" to shut down the child's bids). However, for parents who can balance both internal and external demands in the moment of parenting, their internal emotional equilibrium would likely be restored as they try to address the parenting challenge in a child-centered manner. That is, when

parents show higher levels of responsiveness, their RSA levels are expected to increase, reflecting a recovery from perturbation.

The feedback process described above, that is, how parents' internal emotional states change as they engage in specific parenting behaviors, has received little attention in the literature. However, it may be closely related to some well-documented constructs associated with parenting experience. For instance, parents with higher self-efficacy may demonstrate a stronger feedback process. These parents are more confident in their ability to cope with child-related challenges (Jones & Prinz, 2005). Therefore, as they engage in behavioral responses to their children, their internal states may quickly recover from perturbation. On the contrary, a weak feedback process may be more common among parents who experience higher levels of parenting stress, which is often associated with a lack of parenting self-efficacy (Crnic & Ross, 2017). If parents manage to be responsive to their child, but those behaviors do not result in a timely dissipation of perturbations to parents' emotional equilibrium (e.g., the child cannot be soothed, or the parent is constantly anxious about the child's states), they may have a less optimal parenting experience. The difficulty in restoring internal emotional equilibrium may eventually lead to heightened stress and fatigue that interfere with cognitive processes (Boksem, Meijman, & Lorist, 2006; Raio, Orederu, Palazzolo, Shurick, & Phelps, 2013), making it hard for parents to maintain their responsiveness to their children in ensuing perturbations. To summarize, the feedback process may play an important role in how parents balance supporting children's well-being and maintaining their own well-being, and warrants more research attention.

The current study

Adopting a dynamic systems approach, the current study presents a conceptual model of parental emotion regulation processes (see Figure 3-1). In the empirical part of this study, I test

the model with second-by-second time-series data of mothers' physiology and behaviors in a challenging parenting situation (i.e., the Wait Task) with a low-risk community sample. Specifically, I use ordinary differential equation (ODE) modeling to examine the dynamic relations among challenging child behaviors, maternal RSA, and maternal responsiveness that reflect the three key dynamic processes described above. ODE models have been widely applied to the study of system functioning and self-regulatory processes (Boker, 2001; Cole, Bendezú, Ram, & Chow, 2017; Steele & Ferrer, 2011). It treats time as a continuous variable rather than defining discrete units of analysis, and is thus more appropriate for modeling processes that do not unfold on a unified time course (e.g., there may be variations in how fast parents respond to challenges).

A two-step analytic approach (Chow, 2019) is adopted in the current study, where I obtain the smoothed estimates of the time-series data (challenging child behaviors, maternal RSA, and maternal responsiveness) and the first derivatives that represent their rates of change (i.e., *velocity*) through functional data analysis, and then model the hypothesized dynamic processes through a set of first-order ODEs within a multilevel modeling framework. Specifically, *perturbation as a function of child behaviors* is represented by how the level of challengingness in children's behaviors moderates the velocity of maternal RSA. The *regulation of parenting behaviors* is represented by how the level of maternal RSA moderates the velocity of maternal responsiveness. The *feedback process to restore equilibrium* is represented by how the level of maternal responsiveness moderates the velocity of maternal RSA. Meanwhile, the intrinsic dynamics of maternal RSA and responsiveness, that is, the tendency for these two variables to return to their set points, are represented by how their levels moderate their own momentary velocity.

After testing the intra-individual dynamic processes (Aim 1), I further examine the inter-individual differences in these processes in association with mothers' overall responsiveness and

subjective negative emotions during the Wait Task (Aim 2), as well as their self-reported use of strategies to manage negative emotions (Aim 3). Additionally, I examine the relation between trait-like measures of adult self-regulation (i.e., effortful control and emotion regulation difficulties) and the dynamic processes involved in parental emotion regulation (Aim 4). Finally, given the potential implication of parents' equilibrium-restoration ability for parenting stress, I examined the relationship between the strength of the feedback process and mothers' self-reported parenting stress in everyday life (Aim 5). Specifically, the following hypotheses were tested:

Aim 1: Examine the intra-individual dynamic processes of parental emotion regulation

Based on the conceptual model and findings of Study 1, I hypothesize that in this community sample of mothers, the presence of more challenging child behaviors would predict momentary decreases in maternal RSA (**Hypothesis 1a**; *perturbation as a function of child behaviors*), lower levels of maternal RSA would predict momentary increases in maternal responsiveness (**Hypothesis 1b**; *regulation of parenting behaviors*), and higher levels of maternal responsiveness would in turn predict momentary increases in maternal RSA (**Hypothesis 1c**; *feedback process to restore equilibrium*). Maternal RSA and responsiveness are also expected to show intrinsic dynamics that represent their tendency to return to set points. For RSA, mothers' average RSA during the Wait Task is seen as the set point. Given the design of the task (i.e., mothers were given questionnaires to complete and told their child to wait), working on questionnaires is seen as the set point for maternal behaviors.

Aim 2: Relations between dynamic processes and overall maternal responsiveness and subjective negative emotions

Aim 2 tests two hypotheses. First, mothers who show stronger regulation of parenting behaviors (i.e., a greater increase in responsiveness when maternal RSA is lower than personal average during the task) would demonstrate higher average levels of responsiveness across the Wait Task (**Hypothesis 2a**). Second, mothers who show a stronger feedback process (i.e., a greater increase in maternal RSA when they show higher levels of responsiveness) would report experiencing lower levels of negative emotions during the Wait Task (**Hypothesis 2b**). These two associations are expected after controlling for the average level of challenging child behaviors during the Wait Task.

Aim 3: Relations between dynamic processes and mothers' strategy-use

As reviewed in Chapter 2, parents may invoke a variety of strategies in an attempt to manage their negative emotions, and these strategies may have unique implications for parents' emotional experiences as well as their parenting behaviors. Consistent with Study 1, the current study focuses on four strategies that have been widely characterized in the literature of adult emotion regulation – reappraisal, distraction, suppression, and rumination. I hypothesize that reappraisal (i.e., look at the situation in a different way) can help parents adopt a more positive perception of the circumstance and prioritize positive parenting goals, and would thus be related to stronger regulation of parenting behaviors and a stronger feedback process (**Hypothesis 3a**). Meanwhile, rumination (i.e., pondering over one's feelings) may immerse parents with their own negative emotions and would be related to weaker regulation of parenting behaviors and a weaker feedback process (**Hypothesis 3b**). The roles of distraction and suppression in the context of

parenting are less clear. Therefore, no specific hypotheses are made regarding their relationship with the intra-individual dynamic processes.

Aim 4: Relations between dynamic processes and trait-like adult self-regulation

Aim 4 examines whether trait-like measures of adult self-regulation unspecific to the context of parenting are related to the dynamic processes of parental emotion regulation. Again, I focus on two constructs that may be relevant to parenting competence – parents' effortful control and emotion regulation difficulties. Specifically, I hypothesize that mothers with better trait-like effortful control would show a stronger regulation of parenting behaviors (**Hypothesis 4a**), whereas mothers with higher levels of trait-like emotion regulation difficulties would show a weaker feedback process reflecting difficulties in restoring equilibrium (**Hypothesis 4b**).

Aim 5: Relations between the feedback process and parenting stress

Aim 5 tests the hypothesis that mothers who experience higher levels of stress during everyday parenting tasks would show a weaker feedback process during the Wait Task (**Hypothesis 5**). Here I do not intend to imply any causal relations but examine whether and how parents' general perception of parenting-related stress may manifest in moment-to-moment dynamics.

Methods

Participants and procedures

The participants and procedures have been described in the Methods section of Chapter 2.

Measures

All the measures used in this study have been described in the Method section of Chapter 2, except for second-by-second RSA and parenting stress that are described below. As the current study focuses on intra-individual processes, the second-by-second measures of challenging child behaviors and maternal responsiveness were not aggregated but treated as time-varying variables. Meanwhile, the variables reflecting inter-individual differences, including the average level of maternal responsiveness during the task, mothers' experience of negative emotions and strategy-use, as well as trait-like measures related to adult self-regulation (i.e., effortful control and emotion regulation difficulties), which have been examined in Study 1, are included to test whether they moderate the intra-individual dynamics.

Second-by-second RSA

The collection and processing of electrocardiography (ECG) signals have been described in Chapter 2. In brief, mothers' ECG data were cleaned using the Mindware HRV software (version 3.1.5; Mindware Technologies LTD., Westerville, OH). The IBI series was then output from Mindware HRV for the calculation of RSA, which was conducted using the RHRV package (Martínez et al., 2017) in R (R Core Team, 2016).

The input IBI series was filtered to remove outliers and then interpolated to generate a series of equidistant IBI values at a sampling frequency of 4 Hz. Second-by-Second RSA estimates were calculated for the entire visit using overlapping 30-second windows that each moved forward 1 second through the interpolated IBI series. The IBI series within each window was subject to a Hamming window function that up-weights the center of the window, and a short-time Fourier transform was applied to obtain an estimate of the power spectrum for the 15th second of the window. Second-by-second RSA was then computed as the natural log of power within the adult respiration frequency band (0.12-0.40 Hz; Berntson, Quigley, & Lozano, 2007).

This approach requires 30 seconds of continuous data to compute the RSA estimate for the 15th second in a given window. In the current sample, as the recording of ECG data was initiated before the start of each task, estimates were available across the entire Wait Task. However, when there is a segment of missing data in the IBI series, the RSA values would be missing from 15 seconds before the segment until 15 seconds after the segment. Among all mothers, about 1.5% of second-by-second RSA values during the Wait Task were missing.

Parenting stress

During the visit, mothers completed the 20-item Parenting Daily Hassles scale (PDH; Crnic & Greenberg, 1990; Crnic & Booth, 1991). Each item of the PDH describes a minor event related to the caring of young children that occurs routinely in family life (e.g., “Being nagged, whined at, complained to”, “The need to keep a constant eye on where the kids are and what they are doing”). Respondents indicate how often each event occurs (i.e., frequency score, rated on a Likert Scale of 1 “rarely” to 4 “constantly”) and how much of a hassle the event has been for them over the past six months (i.e., intensity score, rated on a Likert Scale of 1 “low” to 5 “high”). Both the frequency scale and the intensity scale of PDH have shown good internal

consistency in previous studies, and have been associated with lower satisfaction about parenting experiences and feelings of fatigue (Crnic & Greenberg, 1990; White, White, & Fox, 2009). As the current study is interested in the extent to which mothers find parenting-related situations demanding and stressful, an average of the 20 intensity scores was calculated as an index of parenting stress (Cronbach's $\alpha = .87$ in this sample). With a possible range of 1 to 5, this index ranged from 1.20 to 4.15 in this sample ($M = 2.34$, $SD = 0.58$), suggesting adequate variability in mothers' experience of parenting-related stress in everyday life.

Data preparation and analysis

Taking a dynamic systems approach, the current study applied ODE modeling within a multilevel framework (i.e., seconds nested within individuals) to examine the intra-individual processes of parental emotion regulation as well as the inter-individual differences in these processes. In preparation for the ODE modeling, I first obtained the smoothed time-series estimates for challenging child behaviors, maternal RSA, and maternal responsiveness, in order to reduce the impact of noise on the detection of underlying regularities. Functional data analysis (FDA) was used to generate the smoothed time-series data and derivatives (Ramsay & Silverman, 2005). Given the interest in the first derivatives that represent the rate of change (i.e., *velocity*) of variables, the time-series data were approximated using 5^{th} order B-splines functions with roughness penalty (penalizing the integrated squared 3^{rd} derivative). Guided by the value of generalized cross-validation index, the smoothing parameter λ was set at 0.1 for all three time-varying variables (see Figure 3-2 for an illustration of observed versus smoothed series of challenging child behaviors). The FDA was completed using the 'getdx()' function in the *dynr* R package (version 0.1.15-1; Chow, 2019; Ou, Hunter, & Chow, 2019), which incorporates functions from the *fda* R package (version 2.4.8; Ramsay, Hooker, & Graves, 2009). The

smoothed level and velocity for individual i at time t can be written as $CLB_i(t)$ and $\frac{dCLB_i(t)}{dt}$ for challenging child behaviors, $RSA_i(t)$ and $\frac{dRSA_i(t)}{dt}$ for maternal RSA, and $RES_i(t)$ and $\frac{dRES_i(t)}{dt}$ for maternal responsiveness.

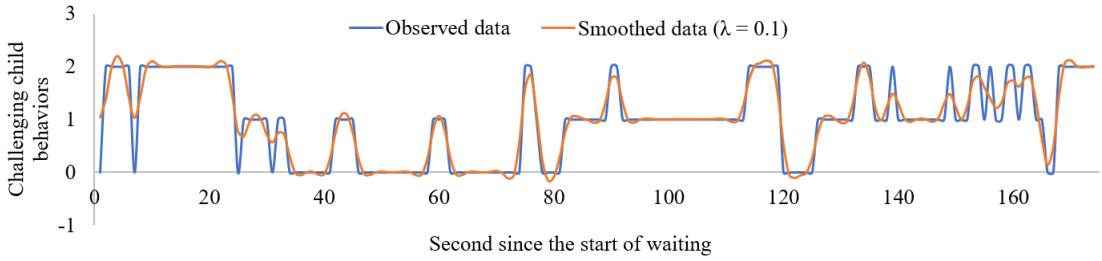

Figure **3-2**: The observed and smoothed time-series data of challenging child behaviors of a randomly selected family during the first waiting session.

Aim 1: Intra-individual processes

The intra-individual processes hypothesized in Aim 1 were tested using a pair of ODE models specified as:

$$\frac{dRSA_i(t)}{dt} = a_{1i} + b_{1i}(RSA_i(t) - \overline{RSA_i}) + p_i CLB_i(t) + f_i RES_i(t) + u_i(t) \quad (1)$$

$$\frac{dRES_i(t)}{dt} = a_{2i} + b_{2i} RES_i(t) + r_i(RSA_i(t) - \overline{RSA_i}) + v_i(t) \quad (2)$$

The velocity of maternal RSA for individual i at time t ($\frac{dRSA_i(t)}{dt}$) was modeled as a function of an intercept (a_{1i}), the level of RSA relative to the personal average $\overline{RSA_i}$ (b_{1i}), the level of challenging child behaviors (p_i), the level of maternal responsiveness (f_i), and the residual $u_i(t)$. Meanwhile, the velocity of maternal responsiveness for individual i at time t ($\frac{dRES_i(t)}{dt}$) was modeled as a function of an intercept (a_{2i}), the level of responsiveness (b_{2i}), the level of RSA relative to personal average (r_i), and the residual $v_i(t)$.

In these two models, the intercept parameters (a_{1i} and a_{2i}) represent the expected velocity of maternal RSA and responsiveness when their levels are at set points and all other predictors are equal to 0. Meanwhile, b_{1i} and b_{2i} reflect the intrinsic dynamics of maternal RSA and responsiveness, that is, how their velocity is predicted by their momentary deviation from set points. For RSA, the average level for each mother during the Wait Task was used as the set point. For maternal responsiveness, a rating of 0 (no observable attention, speech, or other behavior toward their children, usually applied to seconds during which mothers were simply working on questionnaires) was used as the set point. It is expected that b_{1i} and b_{2i} would take negative values, reflecting an intrinsic force for maternal RSA and responsiveness to return to their set points (i.e., *returning strength*).

The *perturbation as a function of child behaviors* is represented by p_i, which is expected to be negative, reflecting a decrease in maternal RSA when child behaviors are more challenging (Hypothesis 1a). The *regulation of parenting behaviors* is represented by r_i, which is also expected to be negative, reflecting an increase in maternal responsiveness when mothers' RSA is lower than their task averages (Hypothesis 1b). The *feedback process to restore equilibrium* is represented by f_i, which is expected to be positive, reflecting an increase in maternal RSA when they exhibit higher levels of responsiveness to their child (Hypothesis 1c).

Each of the person-specific parameters representing intra-individual dynamics or associations (a_{1i}, a_{2i}, b_{1i}, b_{2i}, p_i, r_i, f_i) was further modeled as a function of its sample-average value (γ_{a10}, γ_{a20}, γ_{b10}, γ_{b20}, γ_{p0}, γ_{r0}, γ_{f0}). Meanwhile, three random effects were estimated for the three parameters representing the dynamic processes of interest (e_{pi}, e_{ri}, e_{fi}) to reflect the inter-individual variations in p_i, r_i, and f_i. The three hypotheses in Aim 1 were examined based on estimates of γ_{p0}, γ_{r0}, and γ_{f0}, that is, the intra-individual processes of parental emotion regulation for a prototypical mother in this sample.

Aim 2-5: Inter-individual differences

Based on Aims 2-5, three groups of variables were examined as predictors of the three person-specific parameters (p_i, r_i, f_i) representing the key processes of parental emotion regulation tested in Aim 1. The first group of predictors included the average level of maternal responsiveness and mothers' subjective negative emotions during the Wait Task, with the average level of challenging child behaviors also included as a covariate (Aim 2). The second group included the degrees to which mothers used four specific strategies to manage their negative emotions (Aim 3). The third group included the trait-like measures of adult self-regulation (effortful control and emotion regulation difficulties; Aim 4) and parenting stress (Aim 5). Each group of variables was examined in a separate model (predictors specified in Aims 4 and 5 were tested simultaneously due to the significant correlations among them and that they were all unspecific to the current Wait Task).

For example, to test the hypotheses in Aim 2, the person-specific parameters were modeled as:

$$p_i = \gamma_{p0} + \gamma_{p1}\overline{CLB_i} + \gamma_{p2}\overline{RES_i} + \gamma_{p3}NEG_i + e_{pi}$$

$$r_i = \gamma_{r0} + \gamma_{r1}\overline{CLB_i} + \gamma_{r2}\overline{RES_i} + \gamma_{r3}NEG_i + e_{ri}$$

$$f_i = \gamma_{f0} + \gamma_{f1}\overline{CLB_i} + \gamma_{f2}\overline{RES_i} + \gamma_{f3}NEG_i + e_{fi}$$

where $\overline{CLB_i}$ and $\overline{RES_i}$ represent the average levels of challenging child behaviors and maternal responsiveness during the Wait Task for individual i, and NEG_i represents maternal subjective negative emotions for individual i. All the inter-individual level predictors were centered around sample means.

All models were fit to the 88,331 repeated measures nested within 157 mothers using the *nlme* package (version 3.1–149; Pinheiro, Bates, DebRoy, Sakar, & R Core Team, 2017) in R (R Core Team, 2016), with restricted maximum likelihood estimation and with incomplete data

treated using standard missing-at-random assumptions. Statistical significance was evaluated at $\alpha = 0.05$.

Results

Descriptive analyses of inter-individual differences

Most variables representing inter-individual differences have been examined in Study 1, including the average levels of challenging child behaviors, maternal RSA, and maternal responsiveness, mothers' self-reported negative emotions and strategy-use, and their trait-like emotion regulation difficulties and effortful control. The correlations among them are displayed in Table 2-1. Additional analyses were conducted to examine whether parenting stress in everyday life (which was not included in Study 1) was correlated with these variables. Results suggested that higher levels of parenting stress were associated with higher levels of challenging child behaviors ($r = .23$, $p < .01$) and maternal negative emotions ($r = .21$, $p < .01$) during the Wait Task. Mothers who reported experiencing higher levels of parenting stress also reported ruminating more over their negative emotions during the Wait Task ($r = .25$, $p < .01$), and had higher levels of emotion regulation difficulties ($r = .36$, $p < .01$) and lower levels of effortful control ($r = -.28$, $p < .01$). However, parenting stress was not significantly correlated with the average levels of maternal RSA or responsiveness, nor did it correlate significantly with mothers' use of reappraisal, distraction, and suppression during the Wait Task.

Aim 1: Intra-individual processes

As shown in Table 3-1, Hypothesis 1a (i.e., *perturbation by child behaviors*) was not supported by the data, at least for a prototypical mother in this sample. That is, the velocity of mothers' RSA was not associated with the momentary level of challengingness in children's behaviors observed by research assistants (γ_{p0} = 0.0010, p = .20). However, both Hypothesis 1b and 1c regarding the *regulation of parenting behaviors* and the *feedback process to restore equilibrium* were supported by the data, reflected in how maternal RSA and responsiveness moderated each other's dynamic changes. For a prototypical mother in this sample (i.e., sample-average), there was an increase in maternal responsiveness when maternal RSA was lower than personal average (γ_{r0} = -0.0081, p < .01), and higher levels of responsiveness in turn led to an increase in maternal RSA (γ_{f0} = 0.0081, p < .01). To summarize, although the dynamic changes in maternal RSA appeared to be independent of children's challenging behaviors perceived by research assistants, the data did support a negative feedback loop involving mothers' RSA and their responsiveness to their children.

As expected, both maternal RSA and responsiveness showed a tendency to return toward their set points. For maternal RSA, which was centered around personal averages, the parameter indicating returning strength was significantly negative (γ_{b10} = -0.0009, p = .04). That is, when mothers' RSA was higher than their averages during the Wait Task, their RSA tended to decrease; when their RSA was lower than their averages during the Wait Task, it tended to increase. Similarly, maternal responsiveness showed a tendency to return to 0 (i.e., no observable attention, speech, or other behavior toward their children, usually applied to seconds during which mothers were simply working on questionnaires; γ_{b20} = -0.0037, p = .01). Additionally, based on estimates of the intercepts, during moments when all the predictors in Equation 1 were equal to 0 (i.e., maternal RSA was equal to personal average, child behaviors were not

challenging at all, and maternal responsiveness was also equal to 0), maternal RSA tended to decrease (γ_{a10} = -0.0029, p < .01). There was not a significant increasing or decreasing trend for maternal responsiveness when all the predictors in Equation 2 were equal to 0 (i.e., maternal responsiveness was also equal to 0, and maternal RSA was equal to personal average; γ_{a20} = -0.0016, p = .22).

It is worth noting that although the model based on equation 2 converged, the standard deviation of the random effect estimated in this model ($\sigma_{e_{ri}}$, representing the inter-individual differences in the regulation of parenting behaviors) had a very wide confidence interval (the confidence intervals were asymmetrical because the optimization schemes in the *nlme* package log transfer the standard deviation parameters when deriving the maximum likelihood estimates). That is, the standard error of $\sigma_{e_{ri}}$ was large, suggesting that there was some uncertainty in the estimate of the amount of inter-individual differences in r_i.

Table **3-1**: Parameter Estimates for the Model Examining Intra-Individual Dynamic Processes (Aim 1)

Fixed Effect	Estimate (*SE*)	*p*
Equation 1: Predicting RSA velocity		
γ_{a10} (Intercept of RSA velocity)	**-0.0029** (0.0004)	< .01
γ_{b10} (Returning strength of RSA)	**-0.0009** (0.0004)	.04
γ_{p0} (Perturbation by child behavior)	0.0010 (0.0008)	.20
γ_{f0} (Feedback process)	**0.0081** (0.0010)	< .01
Equation 2: Predicting RES velocity		
γ_{a20} (Intercept of RES velocity)	-0.0016 (0.0013)	.22
γ_{b20} (Returning strength of RES)	**-0.0037** (0.0014)	.01
γ_{r0} (Regulation of parenting behaviors)	**-0.0081** (0.0017)	< .01
Random Effect	Estimate	95% *CI*
Standard deviation		
$\sigma_{e_{pi}}$ (Perturbation by child behavior)	0.0074	[0.0062, 0.0089]
$\sigma_{e_{fi}}$ (Feedback process)	0.0103	[0.0088, 0.0120]
$\sigma_{e_{ri}}$ (Regulation of parenting behaviors)	3.0088E-5	[2.7827E-12, 325.3228]
σ_u (Residual of RSA velocity)	0.0899	[0.0895, 0.0904]
σ_v (Residual of RES velocity)	0.3434	[0.3418, 0.3451]
Correlation		
$r(e_{pi}, e_{fi})$	-0.1589	[-0.2956, -0.0159]

Note. *CI* = Confidence interval; RES = Maternal Responsiveness; Feedback process = Feedback process to restore equilibrium. The estimate of $\sigma_{e_{ri}}$ was very small and was thus written in scientific notation. Statistically significant fixed effect coefficients were bolded.

Aim 2-5: Inter-individual differences

Aim 2: Maternal responsiveness and subjective negative emotions

As shown in Table 3-2 (predictor group 1), Hypothesis 2a did not receive strong support based on the current data. Although the value of r_i was more negative as predicted (indicating a stronger *regulation of parenting behaviors*) among mothers with higher average levels of responsiveness, the association did not reach statistical significance (coefficient = -0.0117, p = .06). Hypothesis 2b was supported by the data, such that the value of f_i was lower (indicating a weaker *feedback process to restore equilibrium*) among mothers who reported feeling more negative emotions toward how their children handled the wait (coefficient = -0.0017, p = .04). For example, while the sample-average f_i was estimated to be γ_{f0} = 0.0081 (i.e., with all inter-individual predictors equal to sample means), for mothers whose level of subjective negative emotions was one standard deviation above sample mean (i.e., 1.30 + 1.25 = 2.55, on an observed range of 0-5.33; see Table 2-1 for descriptive statistics), their parameter f_i was estimated to be 0.0081 + 1.25 × (-0.0017) = 0.0060.

The average level of challenging child behaviors during the Wait Task was included as a covariate and was not associated with any of the three parameters reflecting the intra-individual processes of parental emotion regulation (see Table 3-2). Mothers' subjective negative emotions were not associated with the perturbation process (coefficient = -0.0002, p = .69) or the regulation of parenting behaviors (coefficient = 0.0007, p = .66). The average level of maternal responsiveness was not related to the strength of the feedback process (coefficient = -0.0030, p =

.39). Interestingly, however, it was significantly related to perturbation as a function of observed challenging child behaviors (coefficient = -0.0067, $p < .01$). Specifically, while the sample-average p_i was estimated to be γ_{p0} = 0.0010 (i.e., with all inter-individual predictors equal to sample means), for mothers whose level of responsiveness was one standard deviation above sample average (i.e., 0.59 + 0.47 = 1.06, on an observed range of 0-2.46), the parameter p_i was estimated to be 0.0010 + 0.47 × (-0.0067) = -0.0021. That is, mothers with higher average levels of responsiveness during the Wait Task actually showed the hypothesized *perturbation process as a function of child behaviors*, i.e., a momentary decrease in RSA when their children's behaviors were rated as more challenging.

Aim 3: Mothers' strategy-use

Hypothesis 3a was not supported by the data. Although the value of r_i was more negative (indicating a stronger *regulation of parenting behaviors*) among mothers who reported using more reappraisal, the association did not reach statistical significance (coefficient = -0.0015, $p = .07$). No association was found between reappraisal and the perturbation process (coefficient = 0.0005, $p = .19$) or the feedback process (coefficient = -0.0001, $p = .91$). Hypothesis 3b was not supported either. Although there was an association between rumination and a weaker feedback process as predicted, it also failed to reach statistical significance (coefficient = -0.0007, $p = .08$). Rumination was not associated with the perturbation process (coefficient = -0.0001, $p = .69$) or the regulation of parenting behaviors (coefficient = 0.0001, $p = .85$).

No specific hypotheses were tested for whether and how distraction and suppression would be associated with the intra-individual processes involved in maternal emotion regulation. However, there did appear to be an association between distraction and the perturbation process

(coefficient = -0.0009, p = .05), such that mothers who tried to distract themselves more from the upsetting situation were more likely to show a momentary decrease in RSA when their children's behaviors were challenging. Distraction was not related to the regulation of parenting behaviors (coefficient = 0.0004, p = .69) or the strength of the feedback process (coefficient = 0.0006, p = .33). Suppression was not associated with any of the three parameters reflecting intra-individual processes of parental emotion regulation (see Table 3-2).

Aim 4&5: Trait-like adult self-regulation and parenting stress

Hypotheses 4a and 4b, which predicted that mothers' effortful control would be associated with the regulation of parenting behaviors and that mothers' emotion regulation difficulties would be associated with the feedback process, were not supported by the data. No relation was found between either of the trait-like measures of self-regulation and any of the parameters reflecting intra-individual processes of parental emotion regulation during the Wait Task (see Table 3-2).

However, Hypothesis 5 was supported by the data; when entered simultaneously with the two trait-like measures of self-regulation, mothers' self-reported parenting stress was significantly associated with their feedback process to restore equilibrium (coefficient = -0.0054, p < .01). Specifically, mothers who reported experiencing higher levels of stress in everyday parenting tasks showed a weaker feedback process during the Wait Task. For example, while the sample-average f_i was estimated to be γ_{f0} = 0.0081 (i.e., with all inter-individual predictors equal to sample means), for mothers whose parenting stress was one standard deviation above sample average (i.e., 2.34 + 0.58 = 2.92, on an observed range of 1.20-4.15), their parameter f_i was estimated to be 0.0081 + 0.58 × (-0.0054) = 0.0050.

Table **3-2**: Associations Between Predictors and Inter-Individual Differences in the Intra-Individual Processes (Aim 2-5)

Intra-Individual Parameter Inter-Individual Predictor	Estimate of Coefficient (*SE*)	*p*
Predictor Group 1 (Aim 2)		
p_i (Perturbation by child behavior)		
Task-average challenging child behaviors	0.0003 (0.0019)	.87
Task-average maternal responsiveness	**-0.0067** (0.0025)	< .01
Maternal negative emotions	-0.0002 (0.0006)	.69
r_i (Regulation of parenting behaviors)		
Task-average challenging child behaviors	0.0037 (0.0047)	.43
Task-average maternal responsiveness	-0.0117 (0.0063)	.06
Maternal negative emotions	0.0007 (0.0015)	.66
f_i (Feedback process to restore equilibrium)		
Task-average challenging child behaviors	0.0003 (0.0025)	.90
Task-average maternal responsiveness	-0.0030 (0.0035)	.39
Maternal negative emotions	**-0.0017** (0.0008)	.04
Predictor Group 2 (Aim 3)		
p_i (Perturbation by child behavior)		
Reappraisal	0.0005 (0.0004)	.19
Distraction	**-0.0009** (0.0004)	.05
Suppression	-0.0004 (0.0003)	.19
Rumination	-0.0001 (0.0003)	.69
r_i (Regulation of parenting behaviors)		
Reappraisal	-0.0015 (0.0008)	.07
Distraction	0.0004 (0.0009)	.69
Suppression	0.0009 (0.0008)	.26
Rumination	0.0001 (0.0007)	.85
f_i (Feedback process to restore equilibrium)		
Reappraisal	-0.0001 (0.0005)	.91
Distraction	0.0006 (0.0006)	.33
Suppression	0.0001 (0.0004)	.77
Rumination	-0.0007 (0.0004)	.08
Predictor Group 3 (Aims 4&5)		
p_i (Perturbation by child behavior)		
Effortful control	0.0009 (0.0011)	.40
Emotion regulation difficulties	0.0007 (0.0016)	.68
Parenting stress	0.0023 (0.0014)	.11
r_i (Regulation of parenting behaviors)		
Effortful control	0.0018 (0.0024)	.47
Emotion regulation difficulties	-0.0014 (0.0036)	.70
Parenting stress	0.0008 (0.0033)	.80
f_i (Feedback process to restore equilibrium)		
Effortful control	-0.0020 (0.0014)	.13
Emotion regulation difficulties	-0.0007 (0.0021)	.74
Parenting stress	**-0.0054** (0.0018)	< .01

Note. CI = Confidence interval. Statistically significant fixed effect coefficients were bolded.

Discussion

Taking a dynamic systems approach, the current study proposed and tested a model of parental emotion regulation processes, and investigated how the inter-individual differences in these intra-individual processes were associated with measures of parenting competence based on conventional methods (e.g., aggregated measures of parental emotions and parenting behaviors, self-reported measures of parents' trait-like self-regulation). Time-series data collected from mothers and their preschool-aged children during a Wait Task were generally supportive of the hypothesized dynamic processes driving the moment-to-moment changes of mothers' physiological activity and behavioral responsiveness. The inter-individual differences in these dynamic processes further showed unique associations with mothers' overall subjective emotions and responsiveness during the task, their use of strategies to manage negative feelings, as well as self-reported parenting stress. This study provides the first conceptual account of how parents' emotion regulation may unfold in the moment of parenting, enabling them to both support their children and maintain or restore their own emotional equilibrium. The findings highlight the value of time-series data and dynamic analysis to unveiling the potential mechanisms underlying at-risk parenting (e.g., low levels of responsiveness) and less optimal parental experiences (e.g., parenting stress).

Describing the processes of parental emotion regulation

The conceptual model proposed in the current study (Figure 3-1) describes the hypothesized dynamic processes that characterize *well-regulated* parents, defined as parents who respond sensitively to their children and also restore their own emotional equilibrium after being perturbed by child-related challenges. In the empirical test of the model, the *perturbation process*

was operationalized as mothers showing a decrease in RSA when their children demonstrated observable behaviors that would challenge a typical adult. In the current sample, I did find some evidence of such RSA changes as a function of observed challenging child behaviors, but only among mothers who showed a higher than average level of responsiveness during the task. Given that lower maternal RSA was then found to prompt an increase in maternal responsiveness, this finding suggests that the momentary decrease in RSA when facing child-related challenges may an important mechanism underlying higher levels of parental responsiveness in this specific parenting situation. For example, it may indicate that these parents can accurately detect that their children are having difficulty coping with a situation independently (Leerkes, 2010), which provoked parents' physiological readiness to act in response. It should be noted that the Wait Task, although resembling common parenting challenges in everyday life, is distinct from the tasks typically used in developmental research to observe parental responsiveness (e.g., free play, teaching, or disciplinary tasks that pull for intensive interaction). Therefore, an increase in RSA (or a lack of RSA decreases) during challenging moments among mothers showing lower levels of responsiveness does not necessarily mean that they fail to interpret children's cues or are incompetent in attending to children's needs. It is possible that these parents just expect their children to have the ability, or hope their children to have the opportunity, to handle the situation by themselves, and such intention to stay uninvolved may manifest physiologically.

It is also worth noting that in the conceptual model, the "challengingness" of children's behaviors is defined from the parents' perspective (i.e., perceived as challenging by the specific parent). However, in the empirical test, research assistants rated the extent to which children's behaviors would challenge a typical adult, which may not always align with each parent's appraisal. Therefore, while it is difficult to directly access each parent's moment-to-moment appraisal, it is important to recognize that measuring challenging child behaviors based on observations of a third party may limit the power to detect parents' corresponding reactivity.

Although I did not find a sample-average pattern of RSA decreases as a function of observed child behaviors, when mothers' RSA did get lower than their task averages, there was an increase in maternal responsiveness, consistent with the hypothesized *regulation of parenting behaviors*. This finding suggests that when parents' internal states are perturbed from equilibrium in a parenting situation, at least some of them (e.g., mothers in the current sample) manage to react by being more attentive and responsive to their children – a child-centered, adaptive way to cope with parenting challenges. As discussed earlier, such sensitive responses are likely supported by parents' cognitive resources that enable them to monitor and interpret children's behaviors, delay or inhibit prepotent reactions, and tailor behaviors to children's needs. Previous research has provided preliminary evidence linking parents' trait-like cognitive capacity (e.g., working memory, set-shifting) to a lower probability of adopting negative parenting behaviors in challenging parenting situations (Deater-Deckard, Sewell, Petrill, & Thompson, 2010; Sturge-Apple et al., 2019). The current study extends this field of research by inferring how ongoing regulation in the challenging moments of parenting, which is hard to measure directly, may unfold to support parental responsiveness on a moment-to-moment basis. In this relatively low risk and demographically homogeneous sample, there was limited inter-individual variability in the intra-individual process reflecting the *regulation of parenting behaviors*. That is, these mothers rather uniformly showed an increase in responsiveness to their children when their RSA was momentarily lower than their task averages. This potentially explains the relatively weak evidence on the hypothesized relations between inter-individual predictors and the strength of the regulation process. For example, I expected that mothers who reported using reappraisal more and were generally more responsive to their children across the Wait Task would show a stronger regulation process (i.e., a greater increase in maternal responsiveness when maternal RSA was lower). Although results indicated that the directions of those effects were consistent with the hypotheses, neither of them reached statistical significance (*p*s = .06-

.07). It is possible that in samples with more heterogeneity in parenting risks, the inter-individual differences in the regulation of parenting behaviors would be more salient (e.g., parents at risk for child abuse may show a decrease in responsiveness or an increase in harshness when their internal emotional equilibrium is perturbed). Future research could also examine if parents' social cognition (e.g., perception of children's self-regulation capacity, parenting ideology) is related to their regulation of parenting behaviors when facing child-related challenges.

Lastly, the current study accounts for how parents balance the purposes of responding to their children *and* restoring their own emotional equilibrium in the moment of parenting. In this sample, when mothers demonstrated higher levels of responsiveness to their children, their own RSA increased, providing evidence for the hypothesized *restoration of internal equilibrium* in the conceptual model. This finding indicates that parents' attempts to address their children's needs may in turn facilitate the restoration of their own emotional equilibrium that has been perturbed by child-related challenges. This restoration process was weaker among mothers who reported feeling more negative emotions about how their children were handling the wait. Note that mothers' self-reported negative emotions were not associated with the perturbation process. Therefore, although studies have often conceptualized parents' subjective negative emotions as reflecting how *reactive* parents are toward child behaviors (Dix, 1991; Rueger, Katz, Risser, & Lovejoy, 2011), the current findings suggest that the self-reported measures may not capture the variability in the initial activation of emotion, but rather reflect the variability in the ensuing regulation process. Furthermore, the restoration process was weaker among mothers who reported experiencing more stress associated with everyday parenting tasks. Notably, although this sample was demographically homogenous, there was considerable variability in the measure of parenting stress, with the sample average comparable to that of more at-risk samples (e.g., parents of children with ADHD or developmental delays; Ciciolla, Crnic, & West, 2013; Haack et al., 2017). This finding may reflect an important mechanism or manifestation of heightened

parenting stress. That is, these parents may manage to respond sensitively to their children (at least in the laboratory setting), but are less efficient in restoring their own emotional equilibrium in the meantime, and may thus experience accumulating frustration and irritation during everyday parenting challenges. Future research could examine whether the weakened restoration process is also associated with low parenting self-efficacy or parents' anxiety symptoms (e.g., parents are less confident that they could handle the parenting challenges) that may further explain its relation with parenting stress (Crnic & Ross, 2017).

Overall, the current findings provide preliminary support for the conceptual model of the dynamic processes involved in parental emotion regulation. Although they may not exhaustively cover all the organizing patterns driving mothers' emotional and behavioral dynamics, I argue that the three patterns of regularity identified in this study (labeled as *perturbation as a function of child behaviors*, *regulation of parenting behaviors*, and *restoration of internal equilibrium*) reflect the key processes that enable parents to regulate their own emotional arousal while serving the parental role. The unique associations between the inter-individual differences in these dynamic processes and the more general measures of parenting quality and parental experiences also highlight the value of the dynamic approach to obtaining a nuanced understanding of the mechanisms underlying at-risk parenting.

The dynamic versus conventional approaches to parental emotion regulation

The concept of parental emotion regulation has been operationalized and measured in a variety of ways in the literature, such as parents' self-reported trait-like abilities to control emotions and behaviors or the use of strategies in an attempt to manage emotions. These measures may reflect capacities and processes that have unique implications for parenting competence, but it is not clear to what extent they capture variabilities in the actual processes of

parental emotion regulation in the moment of parenting. The findings of the current study provide some evidence on how these conventional measures may or may not map onto the dynamic processes of parental emotion regulation.

First, mothers' self-reported trait-like emotion regulation difficulties or effortful control, despite showing adequate variabilities in this sample, were not associated with the inter-individual differences in the dynamic processes. Based on the results of Study 1, these two measures were not related to mothers' average RSA reactivity or responsiveness across the task either. These findings contrast previous evidence linking these trait-like abilities to self-reported or observed sensitive and supportive parenting behaviors (Shaffer & Obradović, 2017; Verhoeven et al., 2007). It may be the case that the lack of intensive parent-child interaction during the Wait Task has made it harder for inter-individual differences in parenting and parental emotion regulation to fully manifest. However, this also indicates the context-specificity of parental emotion regulation. That is, measures of parents' general ability to manage emotions and behaviors in socially appropriate or goal-directed ways may not represent how effectively they self-regulate in specific parenting situations. Therefore, in clinical settings where professionals often work with parents on how to respond appropriately to their children in specific parenting contexts or moments, it may be helpful to incorporate more context-specific, dynamic assessments of parental emotion regulation, instead of depending on trait-like measures.

Second, this study examined the associations between mothers' strategy-use when they experienced negative emotions during the Wait Task and the three dynamic processes. Note that the analyses could not reflect whether the use of strategies led to specific dynamic patterns or vice versa, but just their shared inter-individual variances. The only statistically significant relation was between distraction and how maternal RSA changed as a function of child behaviors. Specifically, mothers who reported trying to distract themselves from the emotionally provoking situation (e.g., "distract myself with good thoughts", "refocus on my work") were more likely to

show a decrease in RSA when children's behaviors were challenging. It is possible that mothers who were more reactive to child-related challenges (i.e., those who were more easily perturbed by children's behaviors) were more likely to try to take their minds off the situation. There were also some associations in the expected directions that approached statistical significance; mothers' use of reappraisal was related to a greater increase in maternal responsiveness when maternal RSA was lower (i.e., stronger regulation of parenting behaviors), and rumination was related to less increase in maternal RSA when maternal responsiveness was higher (i.e., weaker restoration of internal equilibrium). Future studies could examine whether these associations would be more salient in samples with greater heterogeneity in parenting-related risks.

Collectively, the current findings provide limited evidence that parents' self-reported strategies account for how their regulatory processes unfold on a moment-to-moment basis. As mentioned in the introduction, it is not clear to what extent parents are consciously aware of and can accurately report their engagement of cognitive strategies. Meanwhile, parents' engagement of a strategy does not necessarily reflect the actual effectiveness of this strategy in influencing parents' emotional and behavioral dynamics. Furthermore, when parents report their use of strategies summarized across a parenting task, it is not clear at which moments or under what circumstances they have attempted those strategies. Therefore, although parental self-reported strategies to manage negative emotions may have unique implications for the quality of parent-child interaction (Lorber, 2012; Waters et al., 2020), it is important to recognize that they do not necessarily represent the actual processes of parental emotion regulation in the challenging moments of parenting.

Limitations and future directions

The current study addresses the intra-individual processes of parental emotion regulation beyond the findings based on aggregated measures in Study 1. However, the two studies share the limitations regarding the measurement of maternal strategy-use (i.e., close-ended questions about a limited range of strategies) and the homogeneous nature of the sample (see the Discussion section of Study 1). As discussed throughout the paper, future studies could examine the dynamic processes in more diverse samples or samples with greater heterogeneity in parenting-related risks, to better understand the inter-individual differences in these intra-individual processes. Furthermore, the current study only tested the proposed conceptual model using data collected from mothers and their preschool-aged children during one specific laboratory parenting task. It is important for future studies to examine whether these dynamic processes replicate in different parenting situations (e.g., ones that involve more intensive parent-child interaction or different types of parenting challenges), among other parental figures, and among parents of children at different developmental stages (e.g., infants or adolescents). Lastly, the current study focused on the parent and simply considered the child as a source of external demands. In the next steps, the conceptual model and empirical test could be extended to include the child as an active part of the system to account for parent-child co-regulatory processes.

In addition to replicating and extending the current model, another important direction for future research is to adopt experimental designs to investigate the extent to which these dynamic processes could be manipulated or modulated. For example, studies could examine whether the regulation of parenting behaviors and/or the restoration of parents' internal equilibrium would be influenced for parents who have experienced an acute stressor (e.g., a social speech protocol), or for parents who have been instructed to engage in specific strategies to manage their emotions.

Such studies could then inform preventions and interventions that aim to improve parental emotion regulation and parental responsiveness.

Conclusions

To summarize, the current study introduced a conceptual model of the dynamic processes involved in parental emotion regulation, accounting for how parents may balance the purposes of regulating their own emotional states and responding to their children's needs. Data collected from 157 mother-toddler dyads during a Wait Task provided support for the bi-directional relations between maternal RSA and responsiveness, suggesting that adaptive parental emotion regulation may involve initiating more child-centered, responsive behaviors when perturbed by child-related challenges, as well as restoring internal emotional equilibrium as parents engage in these behaviors. Inter-individual differences in these two dynamic processes, as well as in how parental RSA changes as a function of observed challenging child behaviors, could help explain variances in parents' overall responsiveness and subjective emotions in a specific parenting situation and their parenting stress in everyday life. Furthermore, conventional approaches to measuring parental emotion regulation, including through self-report questionnaires of strategy-use or trait-like self-regulation abilities, may have limited ability to capture variabilities in the dynamic processes of parental emotion regulation in the moment of parenting.

Chapter 4

General Discussion

This dissertation aimed to provide conceptual and empirical accounts of mothers' self-regulation of emotions in the context of challenging child behaviors. It is increasingly recognized that parental emotion regulation plays a role in parenting as well as in parents' well-being (Crandall et al., 2015; Hajal & Paley, 2020; Rutherford, Wallace, Laurent, & Mayes, 2015). However, studies of parental emotion regulation have largely depended on models and measures from the general literature of adult emotion regulation, which do not consider the specific demands in parenting contexts. Furthermore, the theoretical and empirical advances in the research of emotion regulation, such as the context specificity of strategy-use and the dynamic, intra-individual processes of regulation (e.g., Aldao & Nolen-Hoeksema, 2012; Cole et al., 2019), have rarely been incorporated in the study of parental emotion regulation. Based on data collected from mother-child dyads during a Wait Task, the two studies in this dissertation sought to address these gaps and further the field's understanding of parental emotion regulation in the moment of parenting.

The two studies were constructed based on the argument that the relationship between parents' internal emotional states and their actual parenting behaviors may reflect important information about parental emotion regulation. Study 1 examined mothers' self-reported strategies to manage their negative emotions, and how these strategies related to the inter-individual differences in an aspect of maternal emotion regulation, inferred from the relations between indicators of mothers' emotional phenomena and their actual responsiveness to their children. Study 2 proposed a conceptual model of the dynamic processes involved in parental emotion regulation and tested the model in this sample of mothers during the same task. While Study 1 adopted an aggregated approach and provided a general picture of the inter-individual

differences in mothers' emotional indicators (subjective emotions and physiological reactivity), use of strategies, and observed responsiveness during the task, Study 2 took a dynamic systems approach and focused on the intra-individual dynamic associations between mothers' physiological activity and behavioral responsiveness. In the two previous chapters, I have interpreted and discussed the findings of Study 1 and Study 2 in their separate settings. In this chapter, I discuss the new insights gained by comparing the approaches and findings of the two studies.

Interpreting emotional indicators in the moment of parenting

In Study 1, I interpreted mothers' self-reported negative emotions (i.e., "feelings about how my child is handling today's wait") and their average RSA reactivity as reflecting components of their emotional reactivity to the challenging parenting situation, which presumably set stage for parenting behaviors. This reflects the conventional approach of examining aggregated or summarized indicators of parents' emotional phenomena and the unidirectional relation between parental emotion and parenting behaviors. However, the dynamic approach in Study 2 provides an updated view of these measures and their relations with parenting behaviors.

First, while there was no association between mothers' average RSA reactivity and average responsiveness across the task, there were *bidirectional* associations between their moment-to-moment dynamics, consistent with the conceptual model of the ongoing processes involved in parental emotion regulation (see Figure 3-1). This highlights the value of the dynamic approach to revealing the actual processes of emotion regulation reflected in the ebbs and flows of emotions and behaviors that would be obscured by aggregated or summarized measures. Furthermore, these findings bring into question the common interpretations of average RSA reactivity (i.e., the change in average RSA levels from baseline to a challenging task) as

capturing either “physiological reactivity” or “physiological regulation”. Based on the findings of Study 2, some mothers did show a decrease in RSA when their children were challenging, but the ensuing regulatory processes (i.e., reflected in the negative feedback loops between physiological activity and parenting behaviors) enabled them to quickly restore higher levels of RSA as they engaged in responsive parenting behaviors. Therefore, it can be misleading to interpret parents’ average RSA reactivity during a parenting task either as their “reactivity to the challenging parenting situation” or their “physiological regulation”. Rather, average RSA reactivity likely captures a mix of several initial reactivities and subsequent recoveries governed by how parents self-regulate. This may explain the mixed findings regarding the relationship between RSA reactivity and parenting behaviors among studies that measured RSA across longer epochs ranging from 30 seconds to several minutes.

Second, in Study 2, I also found that mothers’ subjective experience of negative emotions was not related to how their RSA changed dynamically as a function of children’s challenging behaviors, but was associated with how efficiently mothers restored equilibrium (i.e., showing increases in RSA) as they engaged in responsive parenting behaviors. This suggests that parents’ self-reported negative emotions toward children’s behaviors, especially when summarized across the duration of a parenting task, may not capture their initial reactivity, but rather reflect the residuals from inefficient regulation. It is possible that the arousal parents experience about child-related challenges only leaves a salient trace in their conscious awareness when coping behaviors (i.e., responding to the child) do not result in a timely restoration of equilibrium. Again, this brings into question the common interpretations of parents’ subjective emotions simply as “precedents” or “prompts” of parenting behaviors. Therefore, the findings of Study 2 shed light on the limitations of Study 1, where mothers’ self-report of negative emotions was used as a measure of their prepotent emotional reactivity to their children’s behaviors. To further understand parents’ subjective emotions in challenging parenting situations, future studies could

try to collect repeated measures (e.g., asking parents to review videos of parent-child interaction and rate their feelings continuously based on memories; Lorber & Slep, 2005) and examine their dynamic relations with children's and parents' behaviors.

Inferring parental emotion regulation processes

Both Study 1 and Study 2 were built on the overarching hypothesis that parental emotion regulation could be inferred from the relation between their prepotent emotional reactivity, or readiness to act, and their actual parenting behaviors. The findings from the two studies provided a consistent picture of this sample of mothers; although there were some inter-individual differences, this sample of mothers could be considered as well-regulated on average. Specifically, Study 1 showed that mothers whose children were more challenging during the Wait Task reported experiencing more negative emotions, but also showed higher levels of responsiveness across the task. After controlling for how challenging their children were, mothers who experienced more negative emotions showed comparable levels of responsiveness with those who reported experiencing less negative emotions. Similarly, Study 2 showed that there was an increase in maternal responsiveness when their physiological activity was perturbed from equilibrium, which in turn facilitated the restoration of equilibrium. Despite this overall consistency, the dynamic approach produced a more nuanced understanding of parental emotion regulation by allowing examinations of the dynamic, multi-directional processes proposed in the conceptual model. As mentioned earlier, the dynamic findings also help elucidate what the aggregated approach may have masked, capturing the potential mechanisms underlying the generally described "low levels of parental responsiveness" or "heightened parental negative emotions and parenting stress".

The conceptual model and empirical test in Study 2 also help connect the research of parenting with the theoretical advances in the fields of self-regulation. For example, the principle of feedback-control and the hypothesis regarding how higher-order value systems (rational and conscious, attending to long-term goals) modulate the dynamics of lower-order systems (intuitive and automatic, driven by short-term goals) have long been applied to the conceptualization of self-regulation processes (Carver & Scheier, 2011; Cole et al., 2019; Gross, 1998b, 2015). Study 2 is among the first to incorporate these theoretical advances with the specific demands of parenting, and to propose and test a set of operationalizations of the dynamic processes in this specific context. This approach further opens the door for a broad range of research questions, to better understand the inter-individual differences as well as longitudinal changes in parenting competence or risks associated with parental emotion regulation.

Implications for Parenting-Focused Prevention and Intervention

Promoting parents' sensitive and constructive responses to their children's needs is a common approach in parenting-focused prevention and intervention programs aiming to improve children's psychosocial adjustment (e.g., Dozier & Bernard, 2017; Olds, 2006; Sanders, 2012). To facilitate the implementation and evaluation of these programs, averaged or aggregated measures of parental emotions or parenting behaviors are not without their unique values. These measures could be used to describe the overall quality of parental experiences or parenting behaviors in a specific parenting situation. There is also a relatively solid research base suggesting that improvements in overall parenting quality mediate the long-term effects of many prevention and intervention programs on children's competence and well-being (Forehand, Lafko, Parent, & Burt, 2014; Sandler, Ingram, Wolchik, Tein, & Winslow, 2015). Therefore, the

conventional approach of measuring aggregated or summarized parental emotions and parenting behaviors can be a convenient and meaningful way to assess program effects.

Meanwhile, a dynamic approach can offer unique perspectives that help researchers and practitioners understand why the programs work (or do not work) for some parents, as well as the specific ways to improve parental experiences and parenting behaviors. The findings of Study 2 suggest that there may be different mechanisms underlying a lack of parental sensitive responses. Some parents may fail to detect that their children are having difficulties coping with a challenging situation independently and thus miss the opportunities to respond. Others may be less efficient in regulating their parenting behaviors, and simply dismiss their children or turn to inappropriate parenting practices when they feel challenged by children's behaviors. Study 2 also points to a potential mechanism – the inefficiency in restoring parents' own emotional equilibrium as they respond to their children's needs – that may underlie heightened parental negative emotions and parenting stress. Understanding these mechanisms can help clinical professionals design more targeted practices.

Furthermore, the dynamic systems approach reveals that the implementation of sensitive parenting and the regulation of parents' internal emotional states are interrelated parts of a functional system, rather than two separated goals or treatment targets. Helping parents understand this holistic view may facilitate the improvement of parenting competence. For example, it could be conveyed to parents that when they feel challenged in a parenting situation, attending and responding to their children's needs can be an effective way to resolve the challenge and make themselves feel better. Additionally, for parents who experience heightened negative emotions or stress in parenting situations, facilitating the efficiency of their equilibrium-restoration process (e.g., helping parents reflect on how their moment-to-moment actions are addressing the parenting challenges) may help prevent the accumulation of negative feelings.

Conclusions

This dissertation demonstrates how the relationship between indicators of mothers' emotional phenomena (e.g., subjective feelings and physiological reactivity) and their actual parenting behaviors, both at the inter-individual and intra-individual levels, could inform us about maternal emotion regulation when facing child-related challenges. The two studies illustrate the value of a context-specific and dynamic approach to examining parental emotion regulation, and call for a reconsideration of how researchers interpret the trait-like or aggregated measures of parental emotion and emotion regulation. I hope that this dissertation serves as a first step toward testing, refining, and extending the process-oriented model of parental emotion regulation in more diverse samples and parenting situations, as well as different application contexts (e.g., assessment of risks, evaluation of treatment).

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Appendix A

The Observational Rating System for Challenging Child Behaviors

This rating scale is adapted from work by Lorber & O'Leary (2005) who defined children's negative behaviors in the situational context of a waiting task. This scale adapts their operational definitions of negative behaviors, by converting the system from binary decisions (child is or is not doing a behavior) to an ordinal rating of the degree to which those behaviors would challenge the typical adult. In our application, the scale is designed to yield a rating that is independent of participant parents' observed behavior but assesses how challenging children's behaviors are in general. This enables us to investigate parental reactions to children's behavior that are not defined by parental action but by physiological changes and/or self-reported emotions and strategies for coping with negative emotions. In our work, the task demands involve the children faced with a problem (broken toy and waiting to open a gift, difficulty solving puzzle).

Challenging behaviors include:

- Verbal bids to parent that appear intended to demand parent's attention or engagement. Note that verbalizations that are not directed to parent, e.g., self-talk, talking to the toy horse, should not be included.
- Whining
- Physically approaching the working parent, including disturbing the parent, e.g., clinging to parent, grabbing parent's pen or questionnaire.
- Violation of task rules, e.g., opening the wrapped gift during Wait task.
- Behaviors that reflect a difficulty to wait, e.g., touching the gift.
- Dangerous behavior, e.g., standing on the chair/table, climbing on window ledge, leaving room.
- Destructive behavior, e.g., tearing at electrodes, throwing objects, kicking furniture. Note that aggressive pretend play that does not endanger objects should not be included.
- Active resistance to parental directives, either verbally or physically.
- Expressing clear negative emotion, e.g., crying, screaming, angry face at parent.

Child Challenging Behaviors Rating System

Score	Level of challengingness	Example
0	***None***	• Playing with toy or working on puzzle. • Exploring the room or self-talks (if child is physically close to parent's table but playing with/paying attention to other things in the room, e.g., poster on the wall, it would be considered as non-challenging).
1	***Minimal***	• Approaching or talking to parent in a minimally demanding way, e.g., standing in

		front of parent's table and looking at parent without making any clear bid; making a calm statement to parent without a clear intention to demand attention or help. • Touching the gift somewhat unintentionally.
2	***Low***	• Asking parent "when will you be done?", "when can I open it?" or "can you help me with the puzzle?" in a less demanding way. • Touching or grabbing the gift but not opening it. • Attempting to distract parent from work but not directly disturbing them.
3	***Moderate***	• Demanding attention or help in a whiny way. • Opening the gift, taking off electrodes, and/or resisting parent's direction ("But I want to open it now"), but not as actively as described in highly challenging. • Directly disturbing parent's work by taking the pen/questionnaire, but not as disruptively or aggressively as described in highly challenging. • Attempting for acts that are potentially dangerous.
4	***High***	• Screaming and crying. • Opening the gift or taking off electrodes in a disruptive way and/or actively resisting parent's direction, e.g., "No! I want to open it now!". • Attacking parent or destructing properties aggressively. • Disturbing parent's work in a disruptive or aggressive manner, e.g., grabbing the pen and throwing it away, blocking the questionnaire while screaming. • Immediately dangerous behaviors, e.g., putting a finger into electric socket, climbing onto a high place.

Appendix B

Items Measuring Parental Use of Strategies during the Wait Task

Items 2 and 6 describe parental use of reappraisal, items 1 and 7 describe distraction, items 4 and 5 describe suppression, and items 3 and 8 describe rumination.

When you feel any negative emotions during this task, what do you do? Please indicate how much you do any of the following:											
	Not at all										Very much
1. Distract myself with good thoughts	0	1	2	3	4	5	6	7	8	9	10
2. Think about situation differently	0	1	2	3	4	5	6	7	8	9	10
3. Keep thinking about the situation	0	1	2	3	4	5	6	7	8	9	10
4. Push negative feelings away	0	1	2	3	4	5	6	7	8	9	10
5. Hide my feelings	0	1	2	3	4	5	6	7	8	9	10
6. Look at the situation in different ways	0	1	2	3	4	5	6	7	8	9	10
7. Refocus on my work	0	1	2	3	4	5	6	7	8	9	10
8. Think over and over about this	0	1	2	3	4	5	6	7	8	9	10

Appendix C

The Observational Rating System for Parental Responsiveness

**Note: This construct was labeled as "parental engagement" during the observational ratings, but the operationalization was consistent with what was described in the paper for parental responsiveness. In the following descriptions, engagement is corresponded to higher levels of responsiveness, whereas disengagement is corresponded to actively dismissing or invalidating children's needs.*

Positive or supportive parenting is a global construct for describing parenting. It usually includes sensitivity (child centered, developmentally appropriate parental engagement with the child) and positive emotion (warmth toward, enjoyment of the child). In the DYN-o-SR research project, we are interested in each of these two aspects of positive parental behavior and are studying each of them separately (see separate Parental Emotion Scale for observed parental positive emotion). This coding scheme is for **parental engagement and ranges from high engagement to high disengagement**. It focuses specifically on the extent to which a parent's attention and/or action toward the child is attempting to acknowledge/address the child's interests and needs, or to dismiss/avoid interacting with the child.

Parental engagement is defined by the parent's display of attentiveness to, interest in, and/or concern about the child, including initiation of interaction or response to child initiation of interaction that reflects child-centered engagement versus dismissive/avoidant attempts.

The upper half of the scale (above 0) is for engagement. It ranges from engagement that is minimal, e.g., simple attention to or monitoring of the child, to more involved, e.g., interacting substantively with the child (see rating scale for further details).

The mid-point of the scale (0) is used when there is no observable attention, verbalization, or behavior toward the child.

The lower half of the scale (below 0) is for disengagement (i.e., dismissive/avoidant behaviors). It ranges from brief indications that the parent is disinterested in child's states or does not wish to engage with child (e.g., shaking head "no" when child asks for help) to avoiding interacting with the child to directly telling the child something that stops an interaction from beginning or continuing.

When using this rating scale, raters must pay attention to the parent's body orientation, verbalizations and vocalizations, facial expression (which is not always visible), and gestures that convey a level of engagement or disengagement. This includes considering the content of parental verbalizations. The rating of behavior that includes speech will depend on the extent to which the verbalization conveys interest in or concern about the child (i.e., engagement) or desire or effort to avoid or end interacting with the child (i.e., disengagement).

Please note that this scale is not designed to judge the appropriateness or kindness of parental engagement in a given moment. Its sole purpose is to describe whether the parent is engaging, disengaging, or neither throughout each second of the task. A parent may engage with the child by saying something that the child does not like—e.g., the parent might tell the child in the wait task "You cannot open that until I'm done. You have to wait," and the child may react angrily. But the parent was engaged. Remember, too, that the parental emotion (facial, vocal) is not to be rated; that is being rated by a separate system.

PARENTAL ENGAGEMENT/DISENGAGEMENT RATING SYSTEM

Score	Definition
3	***Highly engaged*** Parent is fully attentive and engaged with speech, vocalizations (e.g., laughing), and/or physical movements that convey genuine (as opposed to superficial) interest in the child, concern about the child, and/or attempts to help or support the child.
2	***Moderately engaged*** Parent is attentive to and engaged with child, but not as fully as possible; parent shows genuine interest or concern but in not as engaged a way as described in highly engaged.
1	***Slightly engaged*** Parents is somewhat attentive, but interest or concern is low-level and engagement is minimal.
0	***No indication of attempts to engage or disengage*** Parent does not show observable attention, speech, or other behavior toward child.
-1	***Slightly disengaged*** Parent displays hint of trying to disengage or remain disengaged with child.
-2	***Moderately disengaged*** Parent displays indication of trying to disengage or remain disengaged with child, either by simply turning/looking away from child or other behavior suggesting parent wants child to not engage; parent seems to show clear desire to dismiss the child but not as much as could be possible (see highly disengaged).
-3	***Highly disengaged*** Parent displays obvious desire to disengage or remain disengaged with child, either by verbal command/statement or other behavior that directly conveys that parent will not engage and/or child should not engage.

Examples for Each Scale Point

3 Highly engaged

- Parent makes physical contact, interacts with, and/or speaks to child in fully attentive manner (do not consider how child reacts, positively, ignoring, or negatively).
    - Film examples: Parent turns to child and inquires how child is thinking or feeling or handling the film information. Parent may also touch child in a highly engaged way, such as hugging.
    - Wait/puzzle examples: Parent turns to child and elaborates or explains something that shows an attempt to help child understand/cope with the situation. Do NOT consider parent's tone or facial expressions (whether positive or negative); rate only degree of interaction engagement. Parent may ask questions, explain rules, or become involved in child activity with full attention, such as playing the toy or storytelling.

2 Moderately engaged

- Parent engages with child but not as fully as in highly engaged. That is, parent may touch the child, interact with, and/or speak to child, but not as active and attentive as in highly engaged.
    - Film examples: Parent may make turn to look at the child and comment on or ask about the child's experience, but does not turn fully or make extended physical contact. Parent may also touch child in a moderately engaged way, such as gently pat child's hand.
    - Wait/puzzle examples: Child says something, and parent gives a verbal response while peaking at child or looking, e.g., at an object the child refers to (toy, camera, timer), but did not turn fully to child. Parent may turn toward the child, make eye contact, and/or acknowledge child's concern/interest but without more engaged querying, comforting, explaining, or helping.

1 Slightly engaged

- Parent may or may not turn to/look at child but responds minimally.
    - Film/Wait/Puzzle examples: Parent responds but remains oriented to work or movie, any verbalizations or vocalizations to the child are simple, minimal, such as "OK," "yes," "uh-huh" or "hmm". Parent may glance at child as if checking how child is doing without more interaction.

0 No indication of attempts to engage or disengage

- Parent is working on questionnaires or watching movie, not attending to child at all.
- This includes parent continuing to work & ignoring child statements or approach.

-1 Slightly disengaged

- Parent shows hint of trying to disengage from attending to or interacting with child.
    - Film examples: Parent looks at/engages with things other than child and movie.
    - Wait/puzzle examples: Nonverbally, parent hints that they are working and not to be interrupted. For example, parent may look harder at work and/or mumble to self about the questionnaire when child approaches. Parent peeks at the door or timer when child approaches.

-2 Moderately disengaged

- Parent suggests child not to engage, and/or indicates that parent is disinterested in child or not available to engage in interaction.
    - Film examples: Parent suggests that child should focus on movie and not turn to/talk to parent. Parent may move further away when child comes closer.
    - Wait/puzzle examples: Parent directs child away by interrupting the child and stating that child should engage with something/someone else, parent is doing

own work and cannot help, and/or that child has interfered with parent's work. When child walks to the side of parent's table, parent may turn to the other side. Remember: parents were instructed to do their work; disengagement in these tasks is not defined by explaining the rule; it is defined by how the parent explains the rule, e.g., dismissively (versus showing interest in the child).

-3 Highly disengaged

- Parent explicitly and firmly stops child from engaging, and/or indicates that parent does not want to engage at all.
- Film/wait/puzzle examples: Parent tells child in a determined way to stop bidding or coming to parent. Parent actively casts off child's proximity-seeking behaviors, such as pulling away from child or shakes off child's hand.

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EDUCATION

Ph. D. in Human Development and Family Studies **5/2021**
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M. S. in Human Development and Family Studies **6/2018**
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B. S. in Psychology **7/2016**
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FELLOWSHIPS AND AWARDS

- Society for Research in Child Development (SRCD) Student Travel Award **2019**
- International Society for Developmental Psychobiology (ISDP) Travel Award **2018**
- The Kempe Interdisciplinary Summer Research Institute Scholarship **2018**
- Knoll Distinguished Fellowship & Knoll Enhancement Funds, Penn State **2016**
- Academic Scholarship, Beijing Normal University **2013, 2014, 2015**

SELECTED PUBLICATIONS

Zhang, X., Han, Z. R., & Gatzke-Kopp, L. M. (2021). A biopsychosocial approach to emotion-related parenting: Sympathetic and parasympathetic responses to child frustration in a sample of Chinese parents. *Journal of Family Psychology*. Advanced online publication.

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