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THE CONTRIBUTION OF PARENTAL AND DYADIC PHYSIOLOGY
TO CHILD EMOTION REGULATION

A Dissertation in
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by
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ABSTRACT

Parents play a key role in the development of their child’s emotion regulation skills. These skills not only help children to manage their own feelings and experiences, but also help in maintaining healthy, positive relationships with family members and peers. While parents support child emotion regulation in a variety of ways, the current dissertation focused on exploring the unique influence of parents’ moment-to-moment physiological processes.

The goal of the first study was to investigate how the parasympathetic response of mothers to specific child speaking turns was associated with emotion regulatory supportive parenting behavior and interaction quality. This was examined in a sample of 46 mothers and their 3-5 year old children. In response to a negative child speaking turn, an increase in maternal RSA was significantly associated with a higher task-level proportion of maternal affirmation, but this association was only significant among dyads without a history of child maltreatment. Maltreating mothers showed a lower proportion of affirmation regardless of their change in RSA. An increase in maternal RSA also predicted fewer dyadic ruptures throughout the course of the interaction, and this effect did not vary by maltreatment status. No effects were found when mothers were responding to a positive child speaking turn. These findings suggest that among non-maltreating dyads, an increase in maternal RSA following a negative child speaking turn might help mothers to disengage from the negative affect of the situation and devote more of their parenting behaviors to affirming their child than mothers who experienced a decrease in RSA.

The goal of the second study was to examine non-directional concurrent synchrony among 43 mothers and their 9-14 year old children during joint and individual negative emotion-induction tasks and to test the association between synchrony and a specifically prosocial component of child emotion regulation while considering the moderating effect of maternal acceptance of own emotions. Synchrony was measured as the cross-correlation coefficient of
mother and child second-by-second changes in RSA. The mean, range, and distribution of synchrony values observed during both the joint and individual tasks were similar. While sharing a negative emotional experience together in the same room, compensatory (indicated by a negative correlation coefficient) mother-child RSA synchrony predicted higher child prosocial situational responsiveness among children whose mothers had a lower acceptance of their own emotions. Higher maternal acceptance of emotions was associated with higher child prosocial situational responsiveness regardless of maternal RSA response. Compensatory synchrony characterizes dyads for whom when one individual is increasing in RSA, the other is decreasing, and vice-versa. This finding suggests that among dyads who experience a vulnerability in the form of lower maternal acceptance of emotions, the negative effects of this vulnerability can be avoided if mothers and their children experience opposite RSA responses. No effects of synchrony or maternal acceptance of emotion were found when synchrony was calculated during the individual task, suggesting that there is information being communicated from mother to child and vice versa that has unique predictive value for a prosocial component of child emotion regulation.
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Chapter 1

Introduction

The development of emotion regulation skills is of key importance to the overall well-being of children, and parents are considered one of the strongest influences on this developmental process (Laible, Thompson, & Froimson, 2015; Maccoby, 2015; Morris, Silk, Steinberg, Myers, & Robinson, 2007). Parents influence the development of emotion regulation in children through a variety of ways, including how they model and discuss emotion, how they resolve conflict in the home, and how they respond to child behavior (Baker, Fenning, & Crnic, 2011; Morris et al., 2007). A common, well-researched approach to understanding this process has been to use trait-like measures of parenting, such as overall parental warmth, hostility, or degree of emotion modeling (Baker et al., 2011; Daniel, Madigan, & Jenkins, 2016; Morris et al., 2007). However, parents also support emotion regulation in moments of daily conflict and interaction (Laible et al., 2015). Additionally, parental support of child emotion regulation is not only behavioral in nature, as there are physiological processes that underlie and contribute to emotional processes (Morris et al., 2007; Porges, 2001). Thus, the present studies aim to elucidate how two distinct physiological regulatory components of the parent-child interaction contribute to both parenting behaviors that support child emotion regulation, as well as child emotion regulation skills themselves. Study 1 examines parents’ own parasympathetic regulatory response to instances of child speaking turns in an effort to connect the parental physiological response to variability in parenting behaviors that support or do not support child emotion regulation. Study 2 examines a measure of the dyadic regulation that is occurring during parent-child interactions by asking whether physiological synchrony during a shared, compared to an individual, negative
emotional experience is associated with a prosocial child emotion regulation component, and whether this association is moderated by child maltreatment status.

**Emotion Regulation and its Importance for Children’s Well-Being**

Emotion regulation is most commonly defined as the behavioral and physiological processes involved in managing the experience of emotion and includes modulating the intensity and expression of emotion in an effort to respond adaptively and flexibly to stressful or emotional demands (Cole, Michel, & Teti, 1994; Morris et al., 2011; Thompson, 1994). Emotion regulatory processes are often implicated in social interactions, and children who are better able to regulate feelings of hurt and disappointment, cooperate, listen to, and help peers will experience the many benefits of positive peer support as well as positive regard from authoritative adults, both of which will continue to enhance prosocial development (Repetti, Taylor, & Seeman, 2002). In contrast, children who lack these skills are more likely to alienate peers and experience rejection (Blandon, Calkins, Grimm, Keane, & O’Brien, 2010). Sustained rejection can have cascading effects that lead to increased risk for depression, anxiety, academic failure, substance use, and risky sexual behavior (see Blandon et al., 2010; Repetti et al., 2002).

**Parental Physiological Regulation**

As mentioned previously, parents support child emotion regulation through a variety of behaviors during moments of daily interaction with their children, but what is less understood is how parents are regulating themselves in order to execute those parenting behaviors. Underlying parenting practices in the moment are parents’ own physiological regulatory mechanisms. The physiological regulatory response that parents are experiencing during interactions with their
children could help to explain why it is easier for some parents to engage in parenting practices that support emotion regulation while it is much more difficult for others. For instance, if a child is struggling with a cognitive challenge task and responds to a mother’s advice with frustration, hostile looks, or harsh words, it is likely that the mother will be upset by the child’s display of negative emotion or behavior. In order for the mother to respond with a parenting tactic that will support the child in his emotion regulatory efforts, she must regulate her own felt response. Some mothers might be able to respond to their child supportively, while others become too overwhelmed by the situation; differences in the physiological responses that contribute to parents’ own emotion regulation could help explain differences in parenting behaviors.

Cardiac measures are especially suited to estimate the physiological response as it unfolds on a second-by-second basis immediately following a behavioral stimulus such as a negative child emotion or behavior. Respiratory sinus arrhythmia, RSA, measures the parasympathetic influence on the regulation of the heart and is thought to be a physiological index of an individual’s capacity for emotion regulation. RSA reactivity captures the change in RSA that occurs in response to external stimuli and is considered a measure of individual arousal (Beauchaine, 2001; Porges, 2007). As such, if we can learn more about the real-time parental RSA response to a negative child behavior, we might better be able to understand how parents’ physiological regulation is affected by one small moment of a parent-child interaction, and if certain physiological responses are associated with parenting behaviors that support child emotion regulation. This information could then be applied to building regulatory components for parents into parent-child intervention programs, with the ultimate goal of facilitating parent-child interactions that support child emotion regulatory efforts.
Dyadic Physiological Regulation

Another process by which parents can contribute to child emotion regulation is not an individual regulatory process, but a dyadic one. Both children and parents bring individual qualities, beliefs, and skills to their relationship with one another, but when parents and children actually interact with one another, the interaction takes on a quality of its own. This is illustrated by a study involving a mother-child puzzle task where the mother was instructed to coach the child while he or she built a model replica, but mothers were allowed not to touch the blocks. During this interaction, the frequencies of maternal teaching and directive instances alone did not predict mother-rated child behavior regulation; however, a measure of the likelihood that the child would follow the mother’s teaching and directives with compliance positively predicted child behavioral regulation (Lunkenheimer, Kemp, & Albrecht, 2013). Including a dyadic measure in this study provided additional information about child regulation that otherwise would not have been evident.

A measure used to capture the dyadic nature of parent-child interactions is that of synchrony. Synchrony has most often been explored at the behavioral level during interaction and has been defined and measured in a number of ways, including the matching of affect or behavior, mutual responsivity, or maintaining a shared focus during interaction (Harrist & Waugh, 2002; Leclère et al., 2014). Far less common are studies of physiological synchrony among parents and children, and while studies at both the behavioral and physiological use the term “synchrony,” it is unclear whether synchrony at the physiological level can and should be measured within the existing behavioral synchrony framework. Therefore, it is difficult to make any conclusions regarding the effect of parent-child physiological synchrony on child emotion regulation from the few studies that currently exist. Although the number of studies examining physiological synchrony in parent-child interactions is small, these studies do establish an
evidence-base for synchrony in several physiological measures (e.g., heart rate, RSA), and they have begun to explore the adaptive versus maladaptive nature of physiological synchrony by associating synchrony with profiles of risk or in very few cases, using synchrony to predict child emotions and behaviors (Creaven, Skowron, Hughes, Howard, & Loken, 2013; Lunkenheimer, Tiberio, Skoranski, Buss, & Cole, 2018; Suveg, Shaffer, & Davis, 2016; Woody, Feurer, Sosoo, Hastings, & Gibb, 2016). By building upon these studies, it will become possible to elucidate the contexts in which parent-child physiological synchrony supports child emotion regulation.

**Aims of the Dissertation Project**

The present dissertation project sought to further understand how parent and dyadic regulation at the physiological level supports child emotion regulation. This project is organized in the form of two papers. Study 1 aimed to explore the value of one small moment of a parent-child interaction in predicting characteristics of the overall interaction. More specifically, this study aimed to investigate how parental RSA response to moments of negative child speaking turns was associated with a parenting behavior that supports children in their emotion regulatory efforts, that is, the proportion of parental affirming during interaction. The association between parental RSA response and total dyadic ruptures, or the frequency with which the dyad disrupts sequences of matched positivity during their interaction, was also examined, since more ruptures might indicate less time and emotional resources for the reinforcement of positive child regulatory efforts. Additionally, this study considered how child maltreatment status moderated the associations between parental RSA response and parental affirmation or dyadic rupture, as maltreating parents face additional challenges in displaying behaviors that support the emotion regulation of their children. All analyses were also conducted using parental RSA response to a *positive* child speaking turn, in an effort to evaluate the hypothesis that physiological responses to
negative events are particularly meaningful in the prediction of parenting behaviors and dyadic interactions that support child emotion regulation.

Study 2 investigated the influence of dyadic physiological synchrony on a social component of child emotion regulation, specifically prosocial situational responsiveness. The first aim was to report on whether synchrony is a meaningful function of a shared mother-child experience, as opposed to an indication that a mother and child have a common style of reactivity; this was carried out by exploring synchrony during both joint and individual emotion-induction tasks. The second aim was to determine if dynamic RSA synchrony was associated with child prosocial situational responsiveness, and moderation by maternal acceptance of own emotional responses was evaluated, as various forms of RSA synchrony might serve as a buffer against factors that could act as vulnerabilities for poorer child emotion regulation.

Both studies will use a time series approach (Gates, Gatzke-Kopp, Sandsten, & Blandon, 2015; Hansson & Jönsson, 2006) that will extend findings of the current literature where behavioral data were measured “in the moment” but physiological data were most commonly measured in 30-second averages across tasks (Giuliano, Skowron, & Berkman, 2015; Lunkenheimer et al., 2015). RSA will be measured on a second-by-second basis, allowing a measure of physiology that unfolds alongside behavior in real-time. While each of the two studies is unique in its sample, when considered together, the studies will make important contributions to the field by capturing the physiological components of parent-child interactions using an analytical approach that more closely measures the rate at which physiological responses are occurring, and ultimately offering further insight into how parental and dyadic physiological regulatory efforts influence child emotion regulation and the parenting behaviors that support child emotion regulation.
Chapter 2

Study I: Real-Time Maternal Parasympathetic Response Supports Parenting during Interaction: Variation by Maltreatment Status

Introduction

Parents have the opportunity to positively influence the development of their child’s emotion regulation skills, largely through daily moments of interaction beginning early in life and continuing throughout childhood (Laible et al., 2015; Maccoby, 2015; Morris et al., 2007). Developing a sense of autonomous emotion regulation benefits not only children’s social interactions with other children and adults, but has also been related to better academic and mental health outcomes (Côté-Lecaldaire, Joussemet, & Dufour, 2016; Repetti et al., 2002). Alternatively, parents can contribute to poor emotion regulation development through coercive dynamics. Research shows that children who have families in which higher degrees of coercion are present show internalizing and externalizing problems, as well as uncooperative and poor social relationships with peers, all indicative of reduced emotion regulation skills (see Scaramella & Leve, 2004). While research has led to the development of programs aimed at promoting child emotion regulation via greater positive parenting practices (e.g., reduced harsh discipline, more authoritative parenting behaviors, limit setting, and positive reinforcement), little work has been done to understand the regulatory challenges parents face when trying to use these more positive parenting behaviors (Forgatch & Patterson, 2010; Zisser & Eyberg, 2010). Both parents and children are challenged with regulating themselves during conflictual situations, which includes a physiological regulatory response that takes place alongside their external behavioral response. Studying the ways parents and children interact at a micro-level can offer insight into the physiological response parents experience in the midst of conflictual moments with their child.
and the contribution this physiological response makes to both parents’ ability to use emotion regulatory supportive behaviors and the dyads’ ability to interact positively with one another.

**Understanding the Potential for Coercion**

A coercive interaction is established within a family when one member displays an initial aversive behavior, which is met with an aversive behavioral response from an interaction partner (Forgatch & Patterson, 2010). Coercion theory suggests that when parents respond to child aversive behavior with aversive behavior, such as hostility, a cycle of escalating negativity ensues, often ending with the parent withdrawing from the interaction or giving in to the child’s wants. This cycle is mutually reinforcing for both parent and child because the child gets what he or she initially wanted and the parent temporarily no longer has to engage with the child’s aversive behavior (Patterson, 1982; Smith et al., 2014). As Granic & Patterson (2006) suggest based on developmental systems theory, stable coercive patterns among parents and children develop from repeated individual coercive interactions over time. With each successive interaction, the dyad is constrained more and more into this specific pattern of behavior. As such, an opportunity for changing a coercive dynamic among parents and children lies in intervening with individual interactions.

**Supporting Child Emotion Regulation**

When parents and children participate in coercive interactions, the parent is not modelling positive emotion regulation or giving the child the opportunity to practice effective emotion regulation or conflict resolution independently. In fact, the parent is responding in such a way that heightens the child’s initial dysregulation and maladaptive management of negative
emotion, making effective autonomous emotion regulation even more difficult for the child to achieve (Granic & Patterson, 2006; Scaramella & Leve, 2004). Participation in coercive interactions therefore is not only mutually reinforcing of conflictual, dysregulated behavior, but is simultaneously impeding acquisition of emotion regulatory skills, overall contributing to a diminution of critical parental input to the child’s development of these skills that serve as the foundation for positive social interaction across development (Scaramella & Leve, 2004).

Of particular concern to the development of child emotion regulation during interaction is parental affirmation of child emotions and behaviors. When parents respond to their child with affirmation, they are communicating a warm, supportive environment and modelling empathic behavior, which have been shown to support positive social interaction and regulatory effort in children (Eisenberg, Cumberland, & Spinrad, 1998). Additionally, affirming children and exhibiting an understanding of their emotions, actions, and interactive responses builds children’s self-efficacy and confidence in their own adaptive emotion regulatory skills; this efficacy is motivating for children to practice these skills and remain persistent in their regulatory efforts. Alternatively, if parents do not affirm their children’s emotions and regulatory efforts, children will be less likely to develop a sense of autonomy in emotion regulation and have more difficulty successfully engaging these skills not only in the family context, but in peer and academic contexts as well (Bandura, 1977; see Lincoln, Russell, Donohue, & Racine, 2017).

In addition to parental behaviors that support child emotion regulation, it is also important to consider a measure of the dyadic quality of the interaction as a means of supporting emotion regulation. During an interaction, a rupture occurs when either the parent or child breaks a sequence of positive speaking turns with a negative speaking turn. When parents match their child’s positive behavior or speaking turn with a positive behavior of their own, they are communicating approval and encouragement to their child that positively reinforces the child behaviors. This mutual positivity also serves to strengthen the parent-child bond, further
solidifying the parent as a model of appropriate behavior and regulatory strategies for the child (Leclère et al., 2014). If frequent ruptures are occurring, children might receive less reinforcement of their regulatory efforts, as well as have fewer overall opportunities to practice positive regulatory skills, since more time and effort are likely required to attend to the negative affect of the rupture.

**Parent-Child Interaction within the Broader Context of Maltreatment**

Families that are characterized by high risk might be especially vulnerable to coercive dynamics and poor emotion regulation, particularly if the context of risk is child maltreatment. Though not every interaction between a maltreating parent and child will be an instance of maltreatment, in general, parents who maltreat their children are more hostile and controlling during interactions with their children, discourage autonomy and independence, and show less affection and positivity (Skowron et al., 2011; Skowron, Cipriano-Essel, Benjamin, & Pincus, 2013). This greatly reduces the likelihood of affirming one’s child during interaction. Additionally, maltreating mothers seem to be especially resistant to positive change brought about via intervention (Skowron et al., 2011). As such, it is important to understand the regulatory processes of all parents, but especially those with a history of maltreatment, in an effort to understand the physiological process that occurs as parents are interacting with their children to ultimately help these parents more effectively affirm and build their children’s emotion regulatory capacity.
Understanding the Parental Regulatory Response

Children, and not the parents, are often the initiators of interactions that end in a high degree of negativity. Even if the parent is making an undesirable demand or request, it is the child who often introduces a truly negative behavior or verbal impetus to the interaction (Granic & Patterson, 2006; Lunkenheimer, Lichtwarck-Aschoff, Hollenstein, Kemp, & Granic, 2016). However, not all parents whose children initiate a potentially coercive interaction complete the cycle. Little research exists to explain which parents seem able to prevent this escalation of negativity while others cannot, and why. Lunkenheimer et al. (2016) suggest that by analyzing the micro-level processes (e.g., individual interactions) that contribute to a macro-level dyadic behavioral state (e.g., general degree of coercion), we can better understand the development of the coercive cycle. For instance, by studying parents’ responses to child misbehavior during a parent-child problem-solving interaction task, they found that parents who were considered at high-risk for coercive dynamics (defined as higher maternal depression and hostility and greater child externalizing symptoms) showed greater variability in parenting behaviors when their child was off-task compared to on-task, which was suggested to reflect inconsistency in parenting. By examining a single real-time interaction between parents and children, they were able to detect that it was child off-task behavior that specifically predicted inconsistent parenting for these high-risk parents. This finding could then be directly be applied to the development of a practical component of interventions seeking to aid families who are at-risk for coercive dynamics whereby parents are trained to be consistent during moments of child off-task behavior. While this finding supports the study of parental responses to child behavior at the level of the parent-child interaction, the sources of individual differences underlying the parental response remain unknown. Studying how parents are physiologically regulating in the midst of negative child
behaviors would help to elucidate why some parents might be more or less coercive and by extension, more or less supportive of their child’s developing emotion regulation skills.

**Respiratory Sinus Arrhythmia**

Respiratory sinus arrhythmia (RSA) measures the parasympathetically-mediated fluctuation in heart rate during respiration and is thought to be a physiological index of an individual’s capacity for emotion regulation due to its role in regulating arousal as needed to meet changing external demands. RSA reactivity measures the change in RSA over a given period of time or before and after a stimulus, and is therefore often used as an indicator of regulatory effort during a variety of tasks, including cognitive challenge, emotion induction, and social tasks (Beauchaine, 2001; Gentzler, Santucci, Kovacs, & Fox, 2009; Hinnant, Erath, & El-Sheikh, 2015; Porges, 2007). Polyvagal theory suggests that the RSA response is evoked during challenge and stress contexts, as well as in social contexts where regulation is necessary to remain calm and facilitate a social interaction (Porges, 2001; Porges, 2003). A decrease in RSA (i.e., suppression or withdrawal and indicated in the current study by a negative RSA slope) is typically observed in response to challenge in order to increase heart rate independent of the sympathetic system; this allows proper attention allocation and engagement with whatever the challenge may be without engaging the more energy-costly sympathetic response (see Beauchaine, 2001). Alternatively, an increase in RSA (i.e., augmentation and indicated by a positive RSA slope) has been observed during social tasks where it is favorable to facilitate a decrease in heart rate so as to promote a state of calm social engagement or support for one’s interaction partner (Porges, 2003; Skowron et al., 2011).

When a child initiates a negative interaction, most parents would become understandably upset. They face a difficult emotional challenge in which they must override their initial affective
response if they hope to facilitate a constructive interaction with their child that is resolved without escalating to coercion. Within this complex process, we could expect to see either a decrease or an increase in RSA in direct response to child negative behavior, depending on whether the parent is primarily attending to the stressful situation, or attempting to remain calm to encourage positive social interaction. While no study has investigated the exact RSA response that immediately follows a trigger of child negative behavior, one study has observed an increase and decrease in RSA at different time points across the course of a single interaction. When observing mothers and their children interacting throughout a block-building task, Giuliano, Skowron, & Berkman (2015) found that mothers’ RSA first decreased compared to a pre-task baseline, and then steadily increased throughout the rest of the task. These results suggest that mothers may first be engaging with the cognitive task or stressful situation, but then are shifting to serve as social support for their child (Giuliano et al., 2015). Perhaps if parents’ RSA increases immediately following a negative child behavior, this would help them to serve in that social support role for their child, ultimately contributing to a higher proportion of affirming their child over the course of the interaction. Similarly, just as an increase in RSA following a negative child speaking turn might support mothers in their positive parenting behaviors, this same response might also support a more positive dyadic state throughout the interaction. If mothers are able to respond to a negative child speaking turn with an increase in RSA, it is likely that they will be able to maintain this response when they are engaging in an affectively positive exchange with their child, thus ultimately initiating fewer ruptures. Furthermore, if children are experiencing their mothers showing calm, supportive behavior, as is associated with an increase in RSA, they might be less likely to rupture a positive exchange knowing that their mother is ultimately trying to support them.
Capturing Dynamic RSA

Although RSA reactivity is a suitable measure to study emotion regulation processes, it has not traditionally been assessed on a timescale that most closely approximates the rate at which the parasympathetic response actually unfolds. Assessing RSA as the amount of power in the respiratory frequency band requires extracting a single estimate of RSA over time, typically not shorter than 30 seconds, making RSA estimates available only once every 30 seconds (Berntson, Quigley, & Lozano, 2007). Consequently, RSA reactivity has been typically calculated in one of two ways; either as a single value measuring the difference in average baseline RSA and average task RSA (Calkins, Graziano, & Keane, 2007; El-Sheikh, 2001; Skowron et al., 2011), or as a more dynamic measure mapped over several 30-second epochs throughout a task (Fortunato, Gatzke-Kopp, & Ram, 2013; Giuliano et al., 2015). Though estimating RSA every 30 seconds does capture dynamic changes in the RSA response over the course of a task, parasympathetic vagal activation can actually alter heart rate within the very first heartbeat after which an external stimulus occurs (Somsen, Jennings, & Van Der Molen, 2004). In other words, the RSA response is occurring much sooner than 30-seconds into a reaction, and RSA is potentially changing quite rapidly throughout the duration of the task.

A different analytical approach is required if we are to extract RSA at a timescale that allows us approximate its true dynamics. This is worth pursuing especially if we are to use dynamic RSA in an effort to ultimately understand why some parent-child interactions escalate to coercive interactions while others do not. When a child initiates a potentially-coercive interaction with a negative behavior, the parent experiences a reaction to that behavior in a matter of seconds. This reaction and subsequent response serve to contribute to the potentially coercive cycle, if they, too, are negative, or to prevent the coercive interaction if they redirect the child using alternative tactics. To understand the physiological response that accompanies a parent’s reaction
to a child negative behavior, we need to be able to measure RSA in the few seconds immediately following the child’s stimulus instead of 30 seconds into the interaction when both parent and child have already potentially responded to one another several times.

**Current Proposed Study**

Thus, in the current study, we explored mothers’ second-by-second RSA responses to one of their child’s negative speaking turns in order to increase the understanding of the emotion-regulatory challenges parents face when responding to child negative behavior. Specifically, we evaluated whether any particular maternal RSA response (i.e., withdrawal or augmentation) predicted more maternal affirming behavior or fewer dyadic ruptures throughout the interaction, and whether these associations were moderated by child maltreatment status. First, it was hypothesized that an increase in RSA following a negative child event would be associated with greater maternal affirming behavior and fewer dyadic ruptures throughout the interaction, as an increase in RSA supports facial gestures, vocalizations, and attending behaviors that are involved in remaining calm and serving in a supportive role during interaction (Porges, 2003, 2007). It is worth noting, that this hypothesis is only tentative; a decrease in RSA indicates general arousal and while parents might respond to their child with a decrease in RSA indicating that parenting their child is especially taxing or arousing, it does not necessarily mean that they will be unable to parent their child with consistent affirmation throughout the task or that they will experience more ruptures. Our next hypothesis was that any association between maternal RSA response and task proportion of affirmation or task frequency of dyadic rupture would be moderated by child maltreatment, such that dyads with a history of maltreatment would show a smaller proportion of maternal affirming behavior and a larger frequency of dyadic ruptures regardless of RSA response to a negative child event. This hypothesis was based off of literature suggesting that it is
as equally taxing for a maltreating mother to support her child during an increase in RSA as it is for her to engage with the stressful or challenging task (Skowron et al., 2013). To illustrate the significance of maternal RSA response to child negative behavior specifically, a comparison condition was considered, whereby the effect of maternal RSA in response to a positive child behavior on proportion of maternal affirmation and dyadic rupture frequency was also evaluated.

**Methods**

**Participants**

Mother-child dyads were recruited with the requirements that the mother was 18 years of age or older, spoke fluent English, and lived with her 3-5 year old child. Initial recruitment targeted mothers with a documented history of child maltreatment through Child Protective Services. For comparison purposes, dyads with no history of child maltreatment but who were socio-demographically similar to the maltreatment group were recruited through public welfare agencies and a birth announcement database. While 86 dyads completed the physiological assessment, the final sample number is 46 dyads. Of the 86 mothers with physiological data, 3 files were not able to be reprocessed and output in a second-by-second format. There were an additional 37 dyads in which the child did not display a qualifying negative and positive speaking turn. More details on child speaking turns that qualified for analysis in the current study are available below in the “Observational Coding” section. Mother’s average age for this sample was 28.8 years, 91% of mothers were Caucasian, 76% had a high school degree or less, and 73% had incomes at or below $30,000 per year. Children’s average age was 3.6 years, 54% were female, and 76% were Caucasian.
Procedure

Mother-child dyads completed a 2.5 hour laboratory session where upon arrival, they were fitted with electrodes for physiological data collection. The dyads completed a joint puzzle task where the dyad was seated together at a small table and presented with a duplo-block model and additional disassembled blocks to construct a replica. Mothers were instructed to assist their child in building the replica, but were told not to physically touch any of the block pieces.

Observational Coding

The Structural Analysis of Social Behavior (SASB; Benjamin, 1996) was used to code the individual child negative and positive speaking turns that served as the stimuli for the maternal RSA response of interest, as well as task-level proportion of maternal affirming and dyadic rupture frequency. SASB coding involves three steps whereby each of the following is determined: focus (other or self), degree of affiliation (ranging from loving to hostile), and degree of interdependence (ranging from low, i.e., autonomous to high, i.e., controlling/submitting; see Figure 1 below; Giuliano et al., 2015; Skowron, Cipriano-Essel, Benjamin, & Pincus, 2013). For inclusion in the current study, a child had to have had at least one behavior that was coded as a SASB cluster 2-4 (i.e., trusting and relying, considered the positive child speaking turn) and at least one 2-6 (i.e., sulking and appeasing, considered the negative child speaking turn). A single 2-4 and a single 2-6 were chosen as the stimuli for the maternal RSA response. The framework for choosing a qualifying negative and positive event was as follows: There had to be 10 seconds of separation between the negative event and the positive event. If possible, the first coded negative event was chosen so as to avoid an accumulating negative effect. If possible, the first coded positive event was chosen; this positive event was considered as close to a “baseline”
speaking turn as possible. If possible, the negative event came after the positive event in an attempt to avoid spill-over of negative affect. Additionally, the positive speaking turn could not be double-coded as negative, although the reverse was considered acceptable if it was the only negative speaking turn available. Finally, the speaking turns could not occur in the first or last 15 seconds of the interaction due to the methodological requirements of second-by-second RSA processing.

![SASB simplified cluster model](image)

Figure 2-1. SASB simplified cluster model. Adapted from *Interpersonal Diagnosis and Treatment of Personality Disorders* (2nd ed.) by L.S. Benjamin (1996), New York, NY: Guilford Press. Copyright © 1996 by Guilford Press. Reprinted with permission.

**Physiological Data Acquisition and Processing**

Disposable Ag/AgCl electrodes were placed on mothers’ and children’s chests in a modified Lead II placement, on the right clavicle, lower left rib cage, and right rib cage. Electrocardiogram (ECG) data were acquired using Mindware Technologies ambulatory
electrocardiograph MW1000A at a sampling rate of 500 Hz. ECG data were transmitted via a wireless signal to a computer, and the signal was synchronized with video recordings of behavior to allow for time-synchronized coding of ECG and behavioral data.

ECG data were processed offline using Mindware’s HRV (v. 3.0-3.0.15) software. Trained RAs inspected cardiac waves and corrected any misidentified R peaks. After data were cleaned in Mindware, IBI data were processed using the RSAseconds program available freely for download (Gates, 2018; Gates et al., 2015). The RSAseconds program uses the combination of two techniques, peak matched multiple windows (PM MW) and a short-time Fourier transform (STFT), to produce estimates of RSA at every second of a task using 30-second windows, including 15 seconds before and after the focal time point (Gates et al., 2015). Peak matched multiple windows is a multi-tapering algorithm that applies a series of tapers (tapering is the weighting of each time period of interest to maximally weight the range of data with the most observable information) to a spectral analysis that ultimately provides a single estimate within the frequency band of interest. The short-time Fourier transform refers to the calculation of sliding discrete Fourier transforms (which compute the power of heart rate in the respiratory frequency, .12 - .40, i.e., the estimate used to calculate RSA) across overlapping epochs of data across the entire task. The sum of the squared power estimates obtained in the STFT ultimately provides a series of time-varying RSA estimates. Compared to a traditional epoch approach, where epoch 1 would result in an RSA estimate for seconds 1-30 and epoch 2 would result in a RSA estimate for seconds 31-60, the current approach results in an RSA estimate extracted from seconds 1 – 30, an estimate extracted from seconds 2 – 31, and so on. Because the tapering centers the estimate on the center of the window, no estimate of RSA can be produced for the first, or final 15 seconds of the task.
Measures

**Maternal RSA Response**

After obtaining the second-by-second RSA estimates, the linear slope was calculated for the 10 seconds of maternal RSA following both the identified negative and positive child speaking turns. This was carried out using linear regression to predict maternal RSA by time.

**Maternal Proportion of Affirming Behavior**

The task-level proportion of maternal speaking turns that were categorized as 1-2 (i.e., affirming and understanding) of the SASB framework during the *entire* duration of the interaction (i.e., this is not a measure of maternal affirmation immediately following a negative or positive child behavior). Proportion affirmation = total number of 1-2 speaking turns / total number of speaking turns in all clusters excluding self-focused speaking turns.

**Total Ruptures**

A rupture was defined as any instance during the interaction where the mother or child behaved in a way that broke a sequence of 3 or more positive behaviors. For example, there might be a situation where a maternal behavior is classified in cluster 3, then a child behavior in cluster 2, then a maternal behavior in cluster 2, all of which are considered positive clusters. Then if a child behavior is classified in cluster 7, this would be considered a child-initiated rupture. The total ruptures score is the total number of ruptures that were initiated by either the mother or the child during the interaction.
Child Maltreatment

Child maltreatment status was coded as 0 if the mother had no history of child maltreatment and 1 for any documented history of child maltreatment, including physical abuse or neglect, emotional abuse, or involvement in Child and Youth Services.

Maternal Task Average RSA

Average maternal RSA throughout the entire block-building interaction. The length of the block-building task varied by dyad and ranging from 3.5 minutes to 7 minutes, with the $M = 5$ minutes.

Maternal RSA Intercept

Maternal RSA level at the time of the negative or positive child speaking turn, computed with RSAsconds and defined as the second of child speaking onset.

Data Analysis

Linear regression models were conducted using SPSS version 24.0. One model examined the main and moderating effects of maternal RSA slope following a negative child speaking turn on the proportion of affirming behavior that mothers displayed during the interaction (Model 1), while the other model examined the same effects but on the total number of ruptures that occurred during the mother-child interaction (Model 2). Control variables were included in each model based on how well each contributed to the overall fit of the models. Additional models were run examining maternal RSA slope following a positive child speaking turn.
Results

Descriptive statistics and correlations of study variables are found in Table 2-1. Mothers with no history of maltreatment showed a higher proportion of affirming behavior during the interaction with their children ($r = -.37$), as did mothers of older compared to younger children ($r = .31$). Additionally, a more positive maternal RSA slope (i.e., a greater increase in RSA) following a negative child behavior was correlated with a higher proportion of maternal affirming ($r = .38$). Similarly, a positive slope in maternal RSA following a negative child behavior was correlated with fewer dyadic ruptures ($r = -.30$). Finally, maternal task average RSA was positively correlated with maternal RSA level at the start of the child negative speaking turn ($r = .80$). As a comparison, the correlations of maternal RSA intercept and slope after a positive child speaking turn with the study variables were also considered. As seen in Table 2-1, the only significant correlation was between maternal RSA average and RSA intercept ($r = .86$).

Table 2-1. Descriptive Statistics and Correlations of Measures

<table>
<thead>
<tr>
<th>Measures</th>
<th>M (SD)</th>
<th>Observed Range</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Maternal Proportion of Affirmation (0-1)</td>
<td>.14 (.10)</td>
<td>.00-.38</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Total Number of Ruptures</td>
<td>4.48 (2.32)</td>
<td>1-13</td>
<td>-.22</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Child Age</td>
<td>3.63 (.68)</td>
<td>3-5</td>
<td>.31*</td>
<td>-.17</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Maltreatment History</td>
<td>.65 (.48)</td>
<td>0-1</td>
<td>-.37*</td>
<td>.27</td>
<td>-.20</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) Maternal Task Average RSA</td>
<td>5.81 (1.02)</td>
<td>3.54-8.76</td>
<td>-.06</td>
<td>-.14</td>
<td>-.03</td>
<td>-.12</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) Maternal RSA Intercept (N)</td>
<td>5.22 (1.10)</td>
<td>2.68-7.72</td>
<td>-.07</td>
<td>-.22</td>
<td>.10</td>
<td>-.07</td>
<td>.80**</td>
<td>--</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(7) Maternal RSA Slope (N)</td>
<td>-.02 (.11)</td>
<td>-.31-.31</td>
<td>.38**</td>
<td>-.30*</td>
<td>.03</td>
<td>-.17</td>
<td>-.06</td>
<td>-.15</td>
<td>--</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(8) Maternal RSA Intercept (P)</td>
<td>5.29 (1.18)</td>
<td>2.37-8.30</td>
<td>.10</td>
<td>-.24</td>
<td>.02</td>
<td>-.16</td>
<td>.86**</td>
<td>.71**</td>
<td>.08</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>(9) Maternal RSA Slope (P)</td>
<td>.01 (.09)</td>
<td>-.20-.23</td>
<td>.10</td>
<td>-.14</td>
<td>.16</td>
<td>.16</td>
<td>-.19</td>
<td>-.07</td>
<td>.14</td>
<td>.00</td>
<td>--</td>
</tr>
</tbody>
</table>
Note: RSA = respiratory sinus arrhythmia; (N) indicates RSA measurements were taken following a negative child speaking turn, (P) indicates RSA measurements were taken following a positive child speaking turn. For maltreatment history, 1 = a history of maltreatment. 
N = 46. 
*p < .05, **p < .01.

The results of the regression analysis for Model 1 predicting the proportion of maternal affirmation during the parent-child interaction are reported in Table 2-2. Child age, maternal task average RSA, and maternal RSA level at the time of the child negative speaking turn were included as control variables, though none significantly predicted proportion of maternal affirmation. Child maltreatment status and maternal RSA slope were entered as main effects. Mothers who had a history of any type of child maltreatment displayed a greater proportion of affirming behaviors while interacting with their child compared to mothers with no history of child maltreatment. Additionally, maternal RSA slope following a negative child speaking turn significantly predicted maternal affirming behavior. A more positive RSA slope (i.e., greater increase in RSA) was associated with a higher proportion of affirming behavior. This main effects model was significant, $F(5, 40) = 3.53, p = .01$, with an $R^2$ of .31 and an adjusted $R^2$ of .22.

Table 2-2. Regression Model 1 Examining the Relative Contributions of Child Maltreatment and Maternal RSA Response to a Negative Child Speaking Turn in Predicting Task-Level Proportion of Maternal Affirmation

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Age</td>
<td>.04</td>
<td>.02</td>
<td>.26</td>
</tr>
<tr>
<td>Maltreatment History</td>
<td>-.06</td>
<td>.03</td>
<td>-.27*</td>
</tr>
<tr>
<td>Maternal Task Average RSA</td>
<td>.00</td>
<td>.02</td>
<td>-.03</td>
</tr>
<tr>
<td>Maternal RSA Intercept</td>
<td>.00</td>
<td>.02</td>
<td>-.05</td>
</tr>
<tr>
<td>Maternal RSA Slope</td>
<td>.28</td>
<td>.12</td>
<td>.32*</td>
</tr>
<tr>
<td><strong>Moderation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta R^2 = .08$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Adding the interaction of RSA slope X child maltreatment status to Model 1 resulted in a significant improvement (change in $R^2 = .08$) and an overall significant model, $F (6, 39) = 4.02, p < .01$, as the interaction was significant, $\beta = -.46, p < .05$. To interpret the interaction, the association between maternal RSA slope and proportion of maternal affirming behavior was plotted separately for maltreating and non-maltreating mothers. Among mothers with a history of child maltreatment, maternal RSA slope was not associated with proportion of affirmation. However, among mothers with no history of child maltreatment, a positive RSA slope (i.e., increase in RSA) predicted a higher proportion of maternal affirmation during the interaction.

Figure 2-2. Associations between maternal RSA slope following a negative child speaking turn and proportion of maternal affirming and understanding behavior during interaction among mothers who maltreated their children or did not maltreat their children.

Note. RSA = respiratory sinus arrhythmia; figure was plotted at ± 1 standard deviation from the centered mean for maternal RSA slope.
The regression results of Model 2 predicting total number of ruptures are reported in Table 2-3. The overall model was significant, $F (4, 41) = 2.73, p < .05$. The $R^2$ was .21, and the adjusted $R^2$ was .13. Maternal task average RSA and maternal RSA level at the time of the child negative speaking turn were included as control variables, but none significantly predicted number of dyadic ruptures. Child maltreatment status also did not predict number of ruptures.

There was a main effect of maternal RSA slope following the negative child speaking turn. Consistent with the negative correlation among these variables, a more positive RSA slope (i.e., a greater increase in RSA) predicted fewer ruptures among dyads during interaction. The interaction of RSA slope with child maltreatment was tested, but was not a significant predictor of the number of ruptures.

### Table 2-3. Regression Model 1 Examining the Relative Contributions of Child Maltreatment and Maternal RSA Response to a Negative Child Speaking Turn in Predicting Task-Level Number of Ruptures

<table>
<thead>
<tr>
<th></th>
<th>$B$</th>
<th>SE $B$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maltreatment History</td>
<td>1.03</td>
<td>.68</td>
<td>.21</td>
</tr>
<tr>
<td>Maternal Task Average RSA</td>
<td>.42</td>
<td>.56</td>
<td>.19</td>
</tr>
<tr>
<td>Maternal RSA Intercept</td>
<td>-.84</td>
<td>.49</td>
<td>-.40</td>
</tr>
<tr>
<td>Maternal RSA Slope</td>
<td>-6.30</td>
<td>2.93</td>
<td>-.31*</td>
</tr>
</tbody>
</table>

*Note. * $= p < .05$. RSA = respiratory sinus arrhythmia. N = 46. For maltreatment history, 1 = a history of maltreatment.

In order to examine whether a decrease in RSA following any child speaking turn serves as a risk factor for lower maternal affirming and more dyadic ruptures, or whether this risk is specific to instances negative child speaking turns, additional regression analyses were conducted using maternal RSA after a positive child speaking turn. In the regression models, maternal RSA slope following a positive child speaking turn did not predict the proportion of maternal affirming
behavior or the total number of ruptures during the interaction, nor were there any moderating effects (see Tables 2-4 and 2-5).

Table 2-4. Regression Model Examining the Relative Contributions of Child Maltreatment and Maternal RSA Response to a **Positive** Child Speaking Turn in Predicting Task-Level Proportion of Maternal Affirmation

<table>
<thead>
<tr>
<th>Main Effects</th>
<th>$R^2 = .26^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Age</td>
<td>0.03 0.02 0.23</td>
</tr>
<tr>
<td>Maltreatment History</td>
<td>-0.07 0.03 -0.32*</td>
</tr>
<tr>
<td>Maternal Task Average RSA</td>
<td>-0.05 0.03 -0.46</td>
</tr>
<tr>
<td>Maternal RSA Intercept</td>
<td>0.04 0.02 0.44</td>
</tr>
<tr>
<td>Maternal RSA Slope</td>
<td>0.03 0.16 0.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Moderation</th>
<th>$\Delta R^2 = .01$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal RSA Slope X Child Maltreatment</td>
<td>-0.25 0.31 -0.11</td>
</tr>
</tbody>
</table>

*Note. * = $p < .05$, RSA = respiratory sinus arrhythmia.
N = 46.
For maltreatment history, 1= a history of maltreatment.

Table 2-5. Regression Model Examining the Relative Contributions of Child Maltreatment and Maternal RSA Response to a **Positive** Child Speaking Turn in Predicting Task-Level Number of Ruptures

<table>
<thead>
<tr>
<th>Main Effects</th>
<th>$R^2 = .15$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maltreatment History</td>
<td>1.27 0.71 0.26</td>
</tr>
<tr>
<td>Mom Task Average RSA</td>
<td>0.30 0.69 0.13</td>
</tr>
<tr>
<td>Mom RSA Intercept</td>
<td>-0.62 0.59 -0.31</td>
</tr>
<tr>
<td>Mom RSA Slope</td>
<td>-4.04 4.00 -1.6</td>
</tr>
</tbody>
</table>

*Note. * = $p < .05$, RSA = respiratory sinus arrhythmia.
N = 46.
For maltreatment history, 1= a history of maltreatment.
Discussion

This study provided insight into the maternal RSA response as it unfolded second-by-second after a negative child speaking turn. Analyzing physiological measures on a fine-grained time scale such as this provides an opportunity to understand how parents are regulating in the moment while they are interacting with their child, and to further understand how those regulatory responses are associated with parenting behaviors and dyadic characteristics. Despite a small sample size, significant associations with the maternal RSA response to negative child speaking turns were found, evidencing the value of using a truly dynamic measure of RSA. First, a positive RSA slope was associated with a higher task-level proportion of maternal affirmation, while a negative RSA slope was associated with a lower proportion of affirmation. This finding supports Porges’ polyvagal theory whereby an increase in RSA is a component of the social engagement system that serves to inhibit mobilization and foster social communication via behaviors such as calm facial expressions, vocalizations, and listening (Porges, 2007). This suggests that mothers are regulating their own felt emotional response to avoid matching the negativity of their child and instead perhaps shift attention elsewhere. Responding in such a way might put mothers in a better position to avoid reinforcing the child’s negativity and remain calm more often throughout the entire interaction, thus more capable overall of affirming their child.

The above association was qualified, however, by child maltreatment status. First, there was a main effect of child maltreatment status, suggesting that mothers with a history of maltreatment showed a lower proportion of affirming behaviors than mothers with no history of maltreatment. Maltreatment also modified the relationship between maternal RSA slope and maternal affirming, such that this association was only found in non-maltreating dyads. Mothers with a history of child maltreatment had lower proportions of affirming during their interaction with their child regardless of their RSA response to a child negative utterance. Research on
maltreating mothers suggests that this risk factor poses as a particularly difficult one to overcome, even with intervention (Skowron et al., 2011). Maltreating mothers tend to show less positive parenting in the form of less affection and more discouragement of autonomy and independence (Cicchetti & Toth, 2005; Skowron, Kozlowski, & Pincus, 2010). Studies have also suggested that whereas in less risk-exposed parents certain physiological responses might support more positive parenting practices, the very act of parenting is stressful for a maltreating parent, essentially eliminating the potential of a physiological response to buffer against the risk context (Skowron et al., 2013).

Maternal RSA response to a negative child speaking turn also significantly predicted the number of dyadic ruptures that occurred during the parent-child interaction. This finding further supports the role of RSA in Porges’ social engagement system, but does so in a way that supports a more positive dyadic interaction, as opposed to supporting a social interactive style from one individual (e.g., the mother as discussed relative to the previous finding). The extent to which fewer ruptures is indicative of a more overall positive interactional nature, however, should be interpreted with caution. Previous work has suggested that some degree of rupturing during interactions is normal among all dyads regardless of risk, and that perhaps examining other measures such as dyadic repair could offer additional insight the health of the dyad (Skowron et al., 2010).

In order to illustrate the significance of parental RSA response to child negative behavior specifically, a comparison condition was considered. The effect of maternal RSA reactivity following a positive child speaking turn on maternal proportion of affirmation, as well as dyadic rupture frequency, was also evaluated. In this condition, maternal RSA slope did not significantly predict either outcome. This finding highlights the unique nature of child negative speaking turns in evoking physiological responses in mothers that hold predictive value for both mothers’ behaviors during interaction and dyadic characteristics. This finding suggests that it is particularly
important to continue exploring parental physiological regulation surrounding negative child events, as the regulatory effort involved in these events seems especially salient to parenting behaviors and dyadic characteristics that support child emotion regulation and buffer against coercive dynamics.

**Implications for Practice**

For families where maltreatment is not a risk factor, emotion regulatory components for parents could be built into programs that already seek to prevent coercive cycles and build positive parent-child relationships. For instance, several programs already exist that are aimed at preventing the development of or intervening in an already-established pattern of coercive interactions among parents and children. For instance, Parent-Child Interaction Therapy (PCIT) coaches parents in the moment to change the way parents respond to and direct their child during interaction (Zisser & Eyberg, 2010). A newer program that is undergoing pilot testing uses video-based feedback to work with parents to identify moments during interactions with their child where they were positively engaged and promoting effective emotion regulation for their children (Fisher, Frenkel, Noll, Berry, & Yockelson, 2016). However, none of these existing programs directly help parents improve their own regulation during following negative child behavior. Accordingly, understanding how parents respond physiologically in response to an aversive child behavior would help interventionists to incorporate additional parent emotion regulatory components into programs that already seek to prevent coercive cycles and build positive parent-child relationships.

Adding an emotion regulatory component to already existing interventions might not work the same way for maltreating parents as it would for nonmaltreating parents. Given that there was not one particular parental physiological response that served as a buffer against the
negative effects of maltreatment on proportion of parental affirmation or frequency of dyadic rupture, future studies must pay particular attention to the specific stress mechanisms that occur within maltreating parents when they are parenting their children if intervention components are to be successful.

**Limitations & Future Directions**

Several limitations should be considered with this study, perhaps most noteworthy the small sample size, and as a consequence, these findings might be considered preliminary. Due to the difficulty of pairing observational data with second-by-second physiological data, future studies are needed that perhaps oversample in preparation for expected data loss. Further, the main risk factor of interest for this study was child maltreatment; while the results provide unique insight into the regulatory and parenting processes of maltreating parents, further research is needed that examines a wider spectrum of risk, such as low-income but non-maltreating families, or families with parental mental health concerns. Though an association between maternal RSA reactivity and maternal proportion of affirmation or dyadic ruptures was not found among maltreating families in this study, an association might be found among families exposed to less severe risk factors.

Finally, there is great opportunity to further explore the effects of RSA on a second-by-second basis. While only ten seconds of maternal RSA were used in this study, future studies could consider multiple maternal RSA responses to multiple child speaking turns throughout the entire interaction. Second-by-second child RSA could also be included, particularly in an effort to expand upon the state of the dyad and how the physiology of one interaction partner might be affecting the other, and whether this predicts parenting or child behaviors.
Chapter 3

Study II: Parent-Child Physiological Synchrony during a Negative Emotional Experience: Contribution to Child Prosocial Emotion Regulation and Moderation by Maternal Acceptance of Own Emotions

Introduction

Emotion regulation most often conjures images of regulating one’s own anger or excitement, but it is also implicated during every day social interactions with others. For instance, when a friend is experiencing sadness, emotion regulation involves regulating your own emotions at the moment, comprehending that your friend is experiencing sadness, and then attending to and showing support for your friend. Appropriately responding to someone’s display of emotion conveys caring, empathy, and intent to maintain a relationship, all of which have been shown to contribute to positive, long-lasting peer and family relationships (Hastings, Zahn-Waxler, Robinson, Usher, & Bridges, 2000; MacDermott, Gullone, Allen, King, & Tonge, 2010).

The component of emotion regulation that involves appropriately and sensitively responding to the emotions of others is developed throughout childhood and adolescence, largely through interactions with parents (Morris et al., 2007). Parents are children’s earliest and most consistent interaction partners, and thus parent-child interactions serve as opportunities for children to learn to regulate their own emotions, but also to learn how to appropriately respond to the feelings of others. The degree to which parents and children are connected or coordinated during their interactions is related to the effectiveness with which a child has learned appropriate emotional responsiveness and can successfully integrate this skill into the larger toolbox of autonomous emotion regulatory skills. This pattern of dependency or coordination between two closely related individuals during interaction is commonly referred to as synchrony, and has been examined at both behavioral and physiological levels of analysis. Studies of behavioral synchrony
among parents and their children have found consistent associations between higher parent-child behavioral synchrony (i.e., higher dyadic positivity, mutual focus) and lower child externalizing as well as higher social skills, providing some initial support for the role of behavioral synchrony in child emotion regulation (Lunkenheimer, Olson, Hollenstein, Sameroff, & Winter, 2011; Miller-Slough, Dunsmore, Ollendick, & Greene, 2015; Pasiak & Menna, 2015). Physiological synchrony has been examined to a lesser degree, however, with most previous studies having sought to establish that parent-child physiological synchrony is an existing phenomenon and that certain risk factors are associated with lower synchrony (Lunkenheimer, Tiberio, Skoranski, Buss, & Cole, 2018; Palumbo et al., 2017). What the current study aims to achieve, in addition to continuing the investigation into what physiological synchrony is, is to examine the role that physiological synchrony might play in supporting child emotion regulation, specifically the skill of appropriately responding to other’s emotions.

While studies of parent-child synchrony have mostly reported beneficial effects on children’s emotion regulation and prosocial skills, it is possible to imagine situations in which coordinating with a parent while interacting is not always supportive of this social emotion regulatory component. For instance, during interactions that are characterized by a high degree of stress or negativity, parents have to regulate their own emotions in addition to focusing attention on helping their child regulate. If a parent does not effectively regulate his or her emotions, then synchrony with a child might relate to poorer prosocial situational responsiveness since the child is connecting with a dysregulated role model. Many components go into parental emotion regulation, one of which is parental meta-emotion philosophy (PMEP). PMEP encompasses the feelings and thoughts that parents have about their own emotions and the emotions of their children. Higher PMEP, defined as greater emotion awareness, acceptance of own and child’s emotions, and emotion coaching has been associated with better child social skills and worse emotional and behavioral problems (Gottman, Katz, & Hooven, 1996; see Katz, Maliken, &
Parental acceptance of own emotions has received little attention in empirical studies, but could be especially influential in the prosocial responsiveness of children. Parental acceptance of their own emotional responses is considered an indirect emotion-related socialization behavior (ERSB) because the degree to which parents approve of their own emotions influences their children’s expression of emotions, as well as their children’s judgment of others’ emotional experiences (Eisenberg et al., 1998). Accepting and empathizing with emotions enables individuals to be sensitive and respond appropriately to the emotional needs of others in social situations (MacDermott et al., 2010). If this ability is compromised in parents, then a high degree of matched connectivity with their child for whom they are modelling effective regulation might not be in their child’s best interest. However, before specific hypotheses can be generated around the contexts in which parental emotion regulation might interact with synchrony to predict child emotion regulation, it is first necessary to explore the concept of synchrony more deeply and consider the measures most suited to capture this dyadic phenomenon.

**Behavioral Synchrony**

Dyadic behavioral synchrony has been measured in different relationships (e.g., parent-child, marital/romantic couples, and teammates) and at all phases of the lifespan (i.e., early infancy through adulthood) (Chatel-Goldman, Congedo, Jutten, & Schwartz, 2014; Duarte et al., 2013; Harrist & Waugh, 2002). The definition of behavioral synchrony varies across studies, but it is generally defined by a core set of elements, such as mutual responsiveness, matching of affect or behavior, harmony and a smooth-flowing interactional nature; when defined in this way, higher behavioral synchrony typically predicts higher social and emotional functioning (Davis, Bilms, & Suveg, 2017; Kochanska, 1997). For instance, in one study, behavioral synchrony was
defined as the degree to which the parent-child dyad expressed shared meaning and togetherness while discussing a time when they felt upset (rated on a 5-pt Likert scale). Greater synchrony in this situation predicted lower child emotional lability, lower aggression, and higher global functioning following a treatment program for oppositional defiant disorder (Miller-Slough et al., 2015). In another study where young children and their parents participated in block-building and free play tasks, interactional synchrony (defined as mutual focus and balance in leading and following) and shared affect were examined as predictors of child social skills; greater shared positive affect was associated with greater child social skills (Pasiak & Menna, 2015).

While the above studies suggest that the matching of constructs that are considered positive in nature (i.e., sharing meaning during the discussion of a difficult issue, cooperating during challenge tasks, sharing positive affect) supports emotional and behavioral health in children, this prominence of shared positivity as an experimental context for measuring synchrony may offer little insight into the implications of synchrony when one partner is experiencing negative emotion or a high degree of stress during the task. It is possible that parental matching of child negative affect, for example, could prolong the negative emotional state. Although not using the specific term of “synchrony,” research on coercive interactions where both parent and child are mutually focused on negative emotions and where there is reciprocal responding in the form of increasingly escalating negative affect, suggests that synchrony in this context might hamper adaptive behavioral development. In these studies, coercive interactions were associated with negative child outcomes such as increased aggression, antisocial behavior, and poor social and emotional competence (Granic & Patterson, 2006; Scaramella & Leve, 2004). Another example comes from a study of co-rumination among 7th and 10th grade adolescents and their self-identified close friends, where participants identified a current problem they were experiencing and spent time discussing it with their friend (Rose, Schwartz-Mette, Glick, Smith, & Luebbe, 2014). While some aspects of the interaction, including
rehasing the problem and mutual encouragement of each other, predicted higher friendship quality and friendship closeness, greater time spent mutually dwelling on the negative affect associated with the identified problem was predictive of greater depressive symptoms and anxiety. These findings suggest that although certain empathic elements of interactions might be beneficial for relationships, synchrony in negative affect can be associated with more negative mental health outcomes such as internalizing symptoms. It follows then, that in this situation, it might be more adaptive for one’s partner not to match the expressed negative affect, but to instead counter the situation with an opposite positive affective state or even disconnect from one’s partner.

**Synchrony Framework**

The above studies illustrate the difficulty in concluding that the general concept of connectedness, or synchrony in parent-child interactions is “good” or “bad” in its contribution to adaptive child outcomes such as emotion regulation. Using correlations between mother and child constructs at any given time during an interaction, or correlating mother and child time series data for the duration of a task would allow for more comprehensive measurement of synchrony. A correlation can be weak or strong, as well as positive or negative, introducing variability in the forms of synchrony that might be observed, and most importantly, avoiding the restriction of synchrony to the matching of positive affect only. First, a positive correlation would indicate **matched synchrony** where partners match one another’s behaviors or emotions. Matched synchrony can encompass the matching of affectively positive or negative behaviors and emotions. While it makes sense to see adaptive associations between matched synchrony (often referred to as positive coregulation, attunement, or synchrony in the literature) and child outcomes when what is being “matched” is positive emotional expression, these adaptive
associations might be lacking when matching occurs around negative emotional expressions (Carson & Parke, 1996). Next, a negative correlation would indicate *compensatory synchrony*, describing dyads that are still connected in their behavior or emotion, but where instead of matching one another, partners’ behaviors are going in the opposite affective direction and one partner is compensating for the negative reaction of the other. For instance, if a parent responds to a child’s distressed emotions or behaviors with positive support and encouragement instead of with reciprocal distress or negativity, the child might be better able to down-regulate his experience of negative emotion, which contributes to the development of an ability to self-regulate and cope effectively in emotional situations (Fabes, Leonard, Kupanoff, & Martin, 2001; Lougheed et al., 2016). Finally, a correlation might also be nonsignificant or close to zero. This would show *nonsynchrony*, where parent and child behaviors are unrelated to one another during interaction. It is plausible that a nonsynchronous interaction is optimal if the parent is incapable of being positive and supportive in a time of need for a child and can only respond to the child’s negative affect with matched negativity; the child might be protected from further negativity by remaining disconnected from the parent, or nonsynchronous. Another possible scenario is one where a child is angry and instead of responding with encouragement or happiness, a parent might choose to remain affectively neutral in hopes that the child might not escalate in negative emotionality. Alternatively, nonsynchrony might be maladaptive relative to any form of significant synchrony (i.e., matched or compensatory), perhaps indicating that any degree of connectedness to an adult attachment figure is preferable over no connection to a caregiver; this could be tested using the absolute value of the correlation. Ultimately, these three differentiations of synchrony (i.e., matched, compensatory, and nonsynchrony) allow room for distinguishing the contexts in which each particular form of synchrony is associated with beneficial or maladaptive child outcomes.
Physiological Synchrony

Studying synchrony at the physiological level holds the potential to offer further insight into the ways in which parents contribute to their child’s emotion regulatory abilities during interactions since individual physiological reactivity supports the communication of subtle emotional cues that provide one’s interaction partner with valuable information regarding the current situation (Porges, 2007). For example, one individual might convey sadness via raised corners of eyebrows, pouting lips, or a dropped head or slumped shoulders. Another individual might show positive affect via a subtle smile, moderate physical affection towards another, and an open body posture (Cui, Morris, Harrist, Larzelere, & Criss, 2015). These subtle emotional cues communicate how one individual, a mother for instance, is regulating her emotions, and serve as signals to her child as to whether there is cause for concern in their current situation. Her physiological response and subsequent emotional cues also serve as emotion regulation modelling, which over time through repeated interactions, are integrated into the child’s own autonomous regulatory efforts (Ostlund, Measelle, Laurent, Conradt, & Ablow, 2017).

For the purposes of the current study, however, we are not interested in the details of how emotion regulatory cues are communicated from mother to child and from child to mother. We are instead interested in where the dyad has landed in terms of the degree to which their physiological reactivity is connected over the course of a period of time, a trait-like characteristic that has been developed over years through multiple interactions. A recent review of the measurement and modelling of physiological synchrony in dyads refers to this as non-directional concurrent synchrony, where no assumption is made as to which partner is driving the connection (Helm et al., 2018). A number of research studies have shown that there are several factors that go into how connected a dyad is in their physiological reactivity during a variety of tasks, but what has been studied far less is whether and in what contexts certain types of physiological
synchrony meaningfully predict adaptive or maladaptive parent and child behaviors. Thus, the goal of the current study is twofold: first, to study physiological synchrony in mother-child dyads and provide descriptive information about the ways in which mothers and their children are connected during two different task contexts, and second, to determine if a certain type of physiological synchrony is associated with better child outcomes, specifically in the form of better prosocial situational responsiveness.

**Synchrony in Respiratory Sinus Arrhythmia**

Synchrony in respiratory sinus arrhythmia (RSA) is particularly relevant to the study of emotion regulation, as RSA measures the parasympathetically-mediated fluctuation in heart rate during respiration and is thought to be a physiological index of an individual’s capacity for emotion regulation due to its role in regulating arousal as needed to meet changing external demands (Beauchaine, 2001; Porges, 2007). RSA reactivity is measured by an individual’s change in RSA from one point in time to another and is considered an indicator of regulatory effort during a variety of cognitive, emotional, and social tasks (Gentzler et al., 2009; Hinnant et al., 2015; Woltering, Lishak, Elliott, Ferraro, & Granic, 2015; Woody et al., 2016). Polyvagal theory suggests that the RSA response is evoked during challenge and stress contexts, as well as in social contexts where regulation is necessary to remain calm and facilitate a social interaction (Porges, 2001; Porges, 2003). A decrease in RSA (i.e., suppression or withdrawal) is typically observed in response to challenge in order to increase heart rate independent of the sympathetic system; this allows proper attention allocation and engagement with whatever the challenge may be (see Beauchaine, 2001). Alternatively, an increase in RSA (i.e., augmentation) has been observed during social tasks where it is favorable to facilitate a decrease in heart rate so as to
promote a state of calm social engagement or support one’s interaction partner (Porges, 2003; Skowron et al., 2011).

Applying the previously identified framework of synchrony to parent-child synchrony in RSA, matched physiological synchrony would be evident in a dyad in which both partners are either increasing or decreasing in RSA simultaneously. Compensatory synchrony would occur when one partner is increasing in RSA and the other is simultaneously decreasing, or vice versa. These profiles are visually depicted in Figure 1 which was adapted by the authors from Berntson, Cacioppo, Quiglet, & Fabro's (1994) autonomic space model.

![Figure 3-1. Model of matched and compensatory dyadic synchrony.](image)

Evidence of matched, compensatory, and nonsynchrony of RSA has been found, but the findings of a recent study highlight the importance of considering risk factors and context in predicting RSA synchrony (See Appendix for a full review of studies examining cardiac synchrony among parents and their children). Lunkenheimer et al. (2018) found that higher child internalizing and externalizing, as well as higher maternal psychological aggression predicted
compensatory, as opposed to matched, synchrony. They further found that only a teaching task, compared to a free-play and clean-up task, predicted compensatory synchrony. While studies such as this provide information as to what type of synchrony is predicted by risk and contextual factors, it remains unknown whether synchrony in those situations predicts positive or negative parent and child outcomes. For instance, displaying matching synchrony during a free play task might be good for a healthy dyad that is largely exhibiting positive behavior; but, for another dyad where the child is high in externalizing behavior, the mother might be compensating to avoid escalation or continuation of the child’s negativity.

**Capturing RSA Synchrony**

A final consideration in the study of physiological synchrony is the time scale in which it is captured. The majority of studies measuring RSA synchrony in parents and children use a multilevel model approach where the RSA of one individual acts as a predictor of the RSA of the other individual (Liu, Zhou, Palumbo, & Wang, 2016). This is likely due to the fact that assessing RSA as the amount of power in the respiratory frequency band requires extracting a single estimate of RSA over time, typically not shorter than 30 seconds, making RSA estimates available only once every 30 seconds (Berntson et al., 2007). However, because the RSA response begins at the instant of an external stimulus, theoretically, measuring the decrease or increase in RSA as it occurs *in real-time* alongside behavior could offer additional valuable information. It could be particularly important to measure RSA synchrony on a timescale as close to the actual response as possible, since the nuanced patterns of connectedness between two individuals’ RSA responses are based on individual responses that are potentially changing *continually* at every second of the task (Gates et al., 2015). This gain of information was confirmed by Gates et al. (2015) who used an analytical approach to estimating RSA that allowed
for second-by-second estimates, making it possible to capture dynamic RSA as the response is unfolding. Using this approach, an association was found between RSA synchrony and the outcome of interest (marital satisfaction), but this association was not significant when using the more standard estimate of partners’ RSA average (computed from 30-second measurements) across the task. This suggests that there is in fact valuable information to be gained from taking a dynamic approach to the measurement of RSA synchrony.

**Current Study**

The current study sought to explore and deepen the field’s understanding of physiological synchrony as a concept, as well as to extend the existing parent-child emotion regulation literature by examining the associations between mother-child RSA synchrony, maternal emotional acceptance, and child prosocial situational responsiveness. This was carried out via two aims. Aim 1 was to explore and provide descriptive information for RSA synchrony using a correlational time series approach in two different task contexts. In the first context, the mother and child were watching a sadness-inducing film clip together in the same room, whereas in the second context they were each watching a sadness-inducing film clip, but separately in different rooms. Aim 2 was to determine whether a particular form of synchrony (i.e., matched or compensatory) predicts a component of child emotion regulation, that is, prosocial situational responsiveness, outside of the parent-child interaction, and whether this association is moderated by maternal emotion regulation.

It was hypothesized that a range of synchrony values would observed in both joint and individual task contexts, such that some dyads would engage in matched synchrony, some in compensatory synchrony, and some in nonsynchrony. It was also hypothesized that more maternal acceptance of emotions would predict more child prosocial situational responsiveness.
No main effect of RSA synchrony was expected; however, it was hypothesized that during the joint context only, matched synchrony would result in more child prosocial situational responsiveness when maternal emotional acceptance was high, but that compensatory synchrony would predict more child prosocial situational responsiveness when maternal emotional acceptance was low. No significant findings were expected measuring RSA synchrony during the individual context.

Methods

Participants

Participants were 43 children ages 9-14 (\(M = 11\) years) and their maternal caregivers (\(M = 39\) years, range = 27 – 57 years). Due to 2 families having nonviable physiological data, the final sample size for analyses was \(n = 41\). Families were recruited via flyers posted at pediatric offices (25%), schools (10%), public libraries (15%), and church or community events (7%) within several local counties. Families were also recruited via a referral from a family member or friend (15%), as well as via social media posts (24%, e.g., Craigslist, Facebook, and Nextdoor). Three percent of families did not indicate where they received information regarding the study. Families contacted the study office phone number where they were provided more information about the study and screened for eligibility. Families were eligible if the child was 9-14 years old and in the custody of a maternal caregiver. They were ineligible if the maternal caregiver was pregnant or diagnosed with a heart condition. Consistent with the racial demographics of the area, 76% of maternal caregivers were black, 15% were white, and 9% were biracial or other. Additionally, 34% of mothers completed a college degree or higher, 29% had some college experience, 25% completed high school, and 12% had some high school experience. There was
variability in family income, with 38% receiving less than $20,000 per year, 20% receiving $20-35,000 per year, 17% receiving $35-50,000 per year, and 25% receiving over $50,000 per year. Regarding the child participants, 54% were male, 73% were black, 12% were white, and 15% were biracial or other.

Procedure

Mothers and their children completed a 2.5 hour laboratory session. Upon arrival families were given time to acclimate to the laboratory, ask questions, and provide consent and assent. This was followed by the completion of self-report measures of parenting, health behaviors, and emotion regulation. Participants were next fitted with electrodes for physiological data collection and completed two negative emotion induction tasks, one individually and one jointly. For the individual condition, a video clip from *Homeward Bound* was used where one of the main animal characters is trapped in the mud and it seems he will not make it out. For the joint condition, a video clip from *The Lion King* was used where the main animal character’s father is killed; both clips have been used previously in emotion induction tasks and have been validated as inducing affectively negative emotions (Fortunato et al., 2013; Gatzke-Kopp, Jetha, & Segalowitz, 2014; von Leupoldt et al., 2007). Physiological measures (i.e., RSA) were collected continuously throughout individual and joint video tasks. After each video clip, participants completed self-report measures of anxiety. The visit concluded with participants completing self-report measures of stress exposure and trauma symptoms.
**Physiological Data Acquisition**

Disposable Ag/AgCl electrodes were placed on mothers’ and children’s chests in a modified Lead II placement, on the right clavicle, lower left rib cage, and right rib cage. Electrocardiogram (ECG) data used to extract RSA were acquired using the Mindware Technologies Biolab 3.0.13 acquisition system at a sampling rate of 500 Hz.

**RSA Data Pre-Processing**

ECG data were processed offline using Mindware’s HRV (v. 3.0-3.0.15) software. Trained RAs inspected cardiac waves and corrected any misidentified R peaks. IBI data were processed using the RSAseconds program, available freely for download (Gates, 2018; Gates et al., 2015). The RSAseconds program uses the combination of two techniques, peak matched multiple windows (PM MW) and a short-time Fourier transform (STFT), to produce estimates of RSA at every second of a task using 30-second windows, including 15 seconds before and after the focal time point (Gates et al., 2015). Peak matched multiple windows is a multi-tapering algorithm that applies a series of tapers (tapering is the weighting of each time period of interest to maximally weight the range of data with the most observable information) to a spectral analysis that ultimately provides a single estimate within the frequency band of interest. The short-time Fourier transform refers to the calculation of sliding discrete Fourier transforms (which compute the power of heart rate in the respiratory frequency, .12 - .40, i.e., the estimate used to calculate RSA) across overlapping epochs of data across the entire task. The sum of the squared power estimates obtained in the STFT ultimately provides a series of time-varying RSA estimates. Compared to a traditional epoch approach, where epoch 1 would result in an RSA estimate for seconds 1-30 and epoch 2 would result in a RSA estimate for seconds 31-60, the
current approach results in an RSA estimate extracted from seconds 1 – 30, an estimate extracted from seconds 2 – 31, and so on. Because the tapering centers the estimate on the center of the window, no estimate of RSA can be produced for the first 15 seconds and final 15 seconds of the task.

After obtaining the second-by-second RSA estimates, the RSA series were cleaned to ensure that there were an equal number of data points for the mother and child within each individual dyad. This was necessary to complete the next step, which was first-differencing the scores, meaning that an RSA change score was calculated from one second to the next across the time series for both mother and child. This serves two purposes: it removes any linear trends that might impact the correlation between series and allows for examination of dynamic change in RSA across the task (Gates et al., 2015).

Measures

Synchrony in RSA Reactivity

Interpreted as the degree to which an increase (or decrease) in RSA from the previous time point for one individual corresponds to an increase (or decrease) in the other individual at the same time. Because this is measured as a correlation coefficient, the range is -1 to 1, where a score of -1 would indicate that at each time point the change in child RSA corresponds to the opposite change in mother RSA, whereas a score of 1 would indicate that at each time point the change in child RSA corresponds to the same change in mother RSA.
Child Prosocial Situational Responsiveness

Children completed The Emotion Regulation Index for Children and Adolescents (ERICA), and the Situational Responsiveness subscale was examined, $\alpha = .76$. The Situational Responsiveness subscale assesses situationally sensitive and appropriate prosocial emotion expression (MacDermott et al., 2010). This subscale consists of four items, each of which was rated on a 5-pt Likert scale, where 1 = strongly disagree and 5 = strongly agree. All items were focused on how an individual is regulating his or her own emotional response while interacting with another individual who is experiencing emotion (e.g., “When others are upset, I become sad or concerned for them,” “When other kids are friendly to me, I am friendly to them”). A higher score is indicative of better prosocial situational responsiveness.

Maternal Acceptance of own Emotional Responses

Mothers completed the Difficulties in Emotion Regulation Scale (DERS), and the Nonacceptance of Emotional Responses subscale was examined, $\alpha = .89$ (Gratz & Roemer, 2004). This subscale consists of 6 items that evaluate the individual’s acceptance of his or her own emotional responses (e.g., “When I’m upset, I become angry with myself for feeling that way,” “When I’m upset, I feel like I am weak”). Participants indicated how often each item applied to them using a 5-pt Likert scale (1 = almost never/0-10%; 2 = sometimes/11-35%; 3 = about half the time/36-65%; 4 = most of the time/66-90%; 5 = almost always/91-100%). All items were then reverse-scored and summed to indicate Maternal Acceptance of Emotional Responses.
Data Analysis

After preprocessing the data, all final analyses were conducted in SPSS Version 24. First, the mean and range of synchrony values were explored during both the joint and individual mother-child tasks. Next, separate hierarchical linear regression analyses were conducted for the joint and individual tasks using SPSS version 24.0 to examine the main and moderating effects of physiological synchrony and maternal acceptance of own emotions on child prosocial situational responsiveness. Child age, sex, dyadic RSA synchrony, and maternal acceptance of own emotions were entered in Step 1, while the interaction of RSA synchrony and maternal acceptance of own emotions was entered in Step 2.

Results

Descriptive analyses of observed patterns of synchrony are reported in Table 3-1 and illustrated in Figures 3-2 (joint task) and 3-3 (individual task). Synchrony correlation coefficients during the joint task ranged from -.44 to .55 with a $M = .03 (.26)$, while correlation coefficients from the individual task ranged from -.44 to .51 with a $M = .05 (.21)$. Data from 3 dyads were plotted across the length of the task to illustrate patterns exemplifying each of the synchrony profiles (taken from joint task). Fig. 3-4 shows a dyad characterized by the highest observed degree of matched synchrony ($r = .55$), Fig. 3-5 shows a dyad with compensatory synchrony ($r = -.44$), and Figure 3-6 shows a dyad displaying weak, or nonsynchrony, ($r = .001$).
Figure 3-2. Distribution of mother-child RSA synchrony values during **joint** task.

Figure 3-3. Distribution of mother-child RSA synchrony values during **individual** task.
Figure 3-4. Example of matched RSA synchrony in mother-child dyad (joint task).

Figure 3-5. Example of compensatory RSA synchrony in mother-child dyad (joint task).
Measure correlations are reported in Table 1. No significant correlation emerged between maternal emotional acceptance and child prosocial situational responsiveness. Mother-child synchrony was not associated with the age or sex of the child during the joint or individual tasks. RSA synchrony during the joint task did not correlate with maternal emotional acceptance, but it was significantly correlated with children’s prosocial situational responsiveness. Greater compensatory (i.e., negative correlation between mother and child RSA) synchrony correlated with higher prosocial situational responsiveness in children. Additionally, greater compensatory RSA synchrony during the individual task correlated with higher maternal emotional acceptance.
Table 3-1. Descriptive Statistics and Correlations of Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>M (SD)</th>
<th>Observed Range</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Child Prosocial Situational Responsiveness (4-20)</td>
<td>17.32 (2.09)</td>
<td>13 - 20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) Child Sex</td>
<td>1.44 (.50)</td>
<td>0 - 1</td>
<td>.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) Child Age</td>
<td>11.53 (1.68)</td>
<td>9 - 14</td>
<td>.19</td>
<td>.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4) Maternal Acceptance of own Emotions</td>
<td>26.07 (4.16)</td>
<td>10 - 30</td>
<td>.18</td>
<td>-.08</td>
<td>-.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(5) RSA Synchrony (J)</td>
<td>.03 (.26)</td>
<td>-.44 - .55</td>
<td>-.37*</td>
<td>.21</td>
<td>.14</td>
<td>-.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(6) RSA Synchrony (I)</td>
<td>.05 (.21)</td>
<td>-.44 - .51</td>
<td>-.17</td>
<td>-.05</td>
<td>.03</td>
<td>-.32*</td>
<td>.14</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: RSA = respiratory sinus arrhythmia.
*p < .05.
*N = 41.
For Child Sex, 1 = female
For RSA Synchrony, (J) refers to the Joint Task and (I) refers to the Individual Task.

Results of the joint task regression model are reported in Table 3-2. The main effects model was significant, $F(4, 36) = 4.63, p < .01$. The $R^2$ for this main effects model was .34, adjusted $R^2 = .27$. Female sex significantly predicted better child prosocial situational responsiveness. No main effect of maternal acceptance of emotions was found. RSA synchrony was the strongest independent predictor of child prosocial situational responsiveness, such that consistent with the correlation, stronger compensatory (greater negative correlation) synchrony predicted better emotion sensitivity.

Table 3-2. Regression model examining the relative contributions of maternal acceptance of own emotions and dyadic physiological synchrony during the joint task in predicting child prosocial situational responsiveness.

<table>
<thead>
<tr>
<th>Main Effects</th>
<th>$R^2 = .34^{**}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Sex</td>
<td>1.46</td>
</tr>
<tr>
<td></td>
<td>.58</td>
</tr>
<tr>
<td></td>
<td>.35*</td>
</tr>
</tbody>
</table>
The interaction term RSA synchrony x maternal acceptance was added and resulted in a significant improvement in the model, $\Delta F (1, 35) = 6.68, p < .05$, as the interaction term was significant, $\beta = .34, p = .01$. The $R^2$ for this model was .45, adjusted $R^2 = .37$. To interpret the interaction between RSA synchrony and maternal acceptance of emotions, the association between RSA synchrony and child prosocial situational responsiveness was plotted for children whose mothers had higher and lower acceptance of emotions (grouped by ± 1 SD from the mean) (Aiken & West, 1991; Preacher, Curran, & Bauer, 2006). Simple slopes analyses indicated that among mothers higher in emotional acceptance, RSA synchrony was not associated with child prosocial situational responsiveness. However, among mothers lower in emotional acceptance, RSA synchrony was significantly associated with child prosocial situational responsiveness where compensatory synchrony was associated with higher child prosocial situational responsiveness and matched synchrony was associated with lower prosocial situational responsiveness.
Figure 3-7. Associations between mother-child RSA synchrony during the joint task and child prosocial situational responsiveness when mothers had higher compared to lower acceptance of their own emotions.

Note. * = p < .01. RSA = respiratory sinus arrhythmia, β = simple slope.
N = 41. The figure was plotted at ±1 standard deviation from the mean for RSA synchrony and maternal acceptance of emotion.

In order to examine whether synchrony is a meaningful function of the joint experience of watching a negative film clip or an indication that the mother and child have a common style of reactivity, RSA synchrony was also computed from the RSA values of the mother and the child while each watched a negative film clip individually. When entered in the regression model, RSA synchrony did not significantly predict child prosocial situational responsiveness (β = -.12, p = .50), nor did it significantly interact with maternal acceptance of emotion (β = -.12, p = .66) (Table 3-3).
Table 3-3. Regression model examining the relative contributions of maternal acceptance of own emotions and dyadic physiological synchrony during the individual task in predicting child prosocial situational responsiveness.

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>R² = .14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child Sex (1=female)</td>
<td>1.07</td>
<td>.66</td>
<td>.27</td>
</tr>
<tr>
<td>Child Age</td>
<td>.16</td>
<td>.20</td>
<td>.14</td>
</tr>
<tr>
<td>RSA Synchrony</td>
<td>-1.14</td>
<td>1.69</td>
<td>-.12</td>
</tr>
<tr>
<td>Maternal Acceptance of own Emotions</td>
<td>.06</td>
<td>.09</td>
<td>.12</td>
</tr>
<tr>
<td>Moderation</td>
<td>ΔR² = .01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RSAsynch X maternal acceptance</td>
<td>-.23</td>
<td>.52</td>
<td>-.12</td>
</tr>
</tbody>
</table>

Note. * = p < .05, ** = p < .01. RSA = respiratory sinus arrhythmia, synch = synchrony.
N = 41.
For Child Sex, 1 = female.

Discussion

Parents play an important role in the development of emotion regulation in their children (Eisenberg et al., 1998). Some evidence suggests that parent-child behavioral synchrony in the form of matched positivity is predictive of better child functioning, yet there is a paucity of studies investigating whether this is the case for physiological parent-child synchrony. The form of physiological synchrony that is associated with better child emotion regulation might vary from one situation to another depending on factors such as risk status or task (Leclère et al., 2014; Lunkenheimer et al., 2018). Thus, the goal of the current study was to examine RSA synchrony measured during individual and joint negative emotion-induction tasks, and determine if any particular type of synchrony predicted higher child prosocial situational responsiveness, and whether this association differed by maternal acceptance of her own emotions. RSA synchrony was calculated as a correlation between the change in mother RSA from second to second and the change in child RSA from second to second throughout the task.
When examining synchrony during the joint compared to the individual tasks, similar results were found. Both tasks showed an almost identical range and mean value of parent-child synchrony values (i.e., Joint range = -0.44 to 0.55, M = 0.03; Individual range = -0.44 to 0.51, M = 0.05). There are several plausible explanations for the similarity in these two synchrony calculations. Although in one task each individual was alone and in the other task mother and child were together, both tasks involved viewing and reacting to video meant to induce negative emotion. It is reasonable to suggest that mother and child were experiencing similar RSA responses because they were exposed to two videos meant to induce the same emotion in both people. A second potential explanation is that despite viewing the video alone during the individual tasks, mother and child RSA responses were correlated because they are genetically related to one another. It is also possible because the mother and child have a long history of interacting together, they’ve developed similar reactivity profiles over time, such that when exposed to the same content, they will respond in a similarly connected way regardless of whether they are in the same room as one another or not. Because all of these are possibilities, it was necessary to go a step further and determine if the synchrony values calculated during both tasks have predictive value for child prosocial situational responsiveness.

It was hypothesized that when measured during the joint task, matched RSA synchrony would predict higher child prosocial situational responsiveness, but only when maternal emotional acceptance was high; when maternal emotional acceptance was low, it was predicted that compensatory RSA synchrony would predict higher child prosocial situational responsiveness. This hypothesis was partially supported. An association was found between RSA synchrony and child prosocial situational responsiveness where compensatory synchrony predicted higher prosocial situational responsiveness. This association was only found, however, for children whose mothers displayed a lower acceptance of their own emotions. No association was found when mothers displayed higher emotion acceptance. The children of mothers who
showed high emotion acceptance showed high prosocial responsiveness regardless of whether the dyad showed a matched or compensatory pattern of synchrony. This interaction also suggests, however, that while low maternal acceptance of emotion acts as a vulnerability for lower child prosocial situational responsiveness, a mother can protect her child from the contagion of her emotional vulnerability if she is connecting physiologically with her child in a compensatory way.

The above finding fits literature suggesting that the acceptance of emotions is one of several emotion-related socialization behaviors parents can use to support the development of emotion regulatory skills in children (Eisenberg et al., 1998). This acceptance of emotions is particularly relevant to social situations that call for understanding and responding to the emotions of others (Hastings et al., 2000). If mothers have negative thoughts surrounding their own experiences of emotion, they are likely socializing their child in such a way that does not support prosocial emotion regulation, especially when experiencing negative emotions (Katz et al., 2012). If, however, mothers and their children can show compensatory RSA synchrony, the diverging physiological responses might be supporting in the avoidance of an escalating negative response. This is because even though one individual’s decrease in RSA might indicate arousal and engagement with the stressful negative stimulus being experienced, the other individual’s increase in RSA might communicate that their regulatory effort is going towards maintaining a sense of calm and communicating social concern for the other (Porges, 2007).

The lack of effects when RSA synchrony was calculated using mother and child RSA reactivity from their individual tasks suggests that there is a significant phenomenon that occurs while a mother and her child are experiencing and reacting to a negative emotion together. This phenomenon, however, might not have been discovered had synchrony not been examined for its role in predicting a socially-oriented child emotion regulatory component. For a mother, the physiological response that occurs during a negative emotion might take on a different form when
she is in the presence of her child because in that situation she has the added role of emotional
investment in the safety of her child. Whatever subtle cues the child is giving in response to the
negative emotional experience (e.g., furrowed brow, tensed muscles) are being communicated to
the mother and incorporated into her physiological response. Likewise, when a child is sitting
next to the mother during that same experience, assuming the child looks to the mother as an
authoritative figure, the child is receiving information via the mother’s subtle cues that might help
him assess the safety of the situation as well as what an appropriate emotional response might
like. It must also be noted, however, that there was a significant negative correlation found
between RSA synchrony measured during the individual task and maternal acceptance of
emotions. This finding is only preliminary and the association between maternal emotion
acceptance and synchrony as a measure of similarity or difference between maternal and child
RSA responses (independent of the influence of one another’s physical presence/proximity) must
be further investigated.

Limitations and Future Directions

This study served as an initial investigation into the potential association of RSA
synchrony with child emotion regulatory outcomes. RSA synchrony was measured during a
negative emotion-induction task, and it might be that when measured during a positive emotion-
induction task or during a cognitive challenge task, different forms of synchrony are predictive of
higher child emotion regulation. Additionally, due to the intention for this study to serve as a pilot
study for the investigation of dyadic RSA responses among mothers and their children, the
sample size was fairly small, and while the findings were significant, further studies of larger
sample sizes should seek to replicate the effects found in this study.
Further, while RSA was calculated second-by-second, the synchrony measure used for the current study is an overall synchrony value for the task. A dyad’s average synchrony value does not communicate the amount of time or at which time points the dyad is spending in other forms of synchrony. For instance, if a dyad’s synchrony value is a correlation of -.37, we know that their average synchrony profile is compensatory, however, there are portions of the task that they might be spending in matched synchrony. Additionally, a correlation indicating matched synchrony does not offer insight into whether both partners’ RSA is increasing or decreasing together at any given time. Likewise, when a correlation indicates compensatory synchrony, we have not captured which partner’s RSA is increasing and which partner’s RSA is decreasing. While this level of data is theoretically possible to capture, appropriate methodology much be carefully considered, as most studies have not even begun calculating RSA on a second-by-second basis.
Chapter 4

Discussion

The overarching aim of this dissertation was to study how parents’ regulatory responses contribute to their child’s emotion regulation, as well as the contribution to their own parenting practices that support child emotion regulation. This was carried out via two studies.

Study 1 investigated the maternal RSA response immediately following a negative compared to a positive child speaking turn during a mother-child block-building challenge task. In response to the negative child speaking turn, change in maternal RSA predicted task-level proportion of maternal affirmation, but this was qualified by an interaction. Among dyads with no history of child maltreatment, an increase in maternal RSA was significantly associated with a higher proportion of maternal affirmation, but this association was not significant among dyads with a history of maltreatment. Maltreating mothers showed a lower proportion of affirmation regardless of their change in RSA. An increase in maternal RSA also predicted fewer dyadic ruptures throughout the course of the interaction. No associations between maternal RSA response and proportion of affirmation or dyadic ruptures were found when mothers were responding to a positive child speaking turn.

Study 2 explored non-directional concurrent synchrony among mothers and their children during joint and individual negative emotion-induction tasks, and synchrony was measured as the cross-correlation coefficient of mother and child second-by-second changes in RSA. While the mean, range, and distribution of synchrony values observed during both the joint and individual tasks were highly similar, only synchrony during the joint task was associated with child emotion regulation. While sharing a negative emotional experience together in the same room, compensatory mother-child RSA synchrony predicted higher child prosocial situational responsiveness. This main effect was qualified by an interaction, such that among compensatory
synchrony predicted higher prosocial situational responsiveness for children whose mothers had a lower acceptance of their own emotions. Higher maternal acceptance of emotions was associated with higher prosocial situational responsiveness regardless of RSA response.

First, an important aspect of this dissertation was the measure of RSA on a second-by-second basis to more closely capture the parasympathetic response at the rate at which it occurs. This was necessary for Study 1 because RSA synchrony was the physiological measure of interest, and each mother and child were experiencing changes in their RSA at potentially every second throughout the task. The aim of Study 2 was to explore the impact of the maternal RSA response to child speaking turns that occurred during one small 10-second timeframe within an interaction on task-level parenting and dyadic interaction quality. Main effects and interaction effects involving RSA were found in both studies, lending support to the predictive value of second-by-second dynamic RSA, measured both across an entire task (Study 2) and during one small moment within a task (Study 1).

Next, both studies involved the evaluation of physiological effects during two tasks. A comparison condition within an individual study allows for a deeper interpretation of the nature of the effect than would otherwise be possible (Palumbo et al., 2017). For instance, in Study 1, the effect of maternal RSA response on maternal proportion of affirming behavior and on the frequency of dyadic ruptures was analyzed, considering both maternal RSA response to a negative child speaking turn as well as to a positive child speaking turn. Only the maternal RSA response to a negative child speaking turn significantly predicted both outcomes, suggesting something particularly salient about the physiological response that mothers experience during moments of negative child affect. Similarly, in Study 2, the effect of RSA synchrony on child prosocial situational responsiveness was evaluated during joint and individual tasks, with a significant association found only when synchrony was measured during the joint task. This suggests that while synchrony can be calculated to determine the degree of linkage between
mother and child RSA responses to negative emotion, it is the unique synchronous phenomenon that occurs from mothers and their children experiencing such emotional situations together that predicts prosocial outcomes in children. Both of these findings support the added value of examining the dynamic RSA response in multiple conditions, since specific effects are context dependent.

Perhaps most importantly, this project as a whole sought to further the understanding of the processes by which parents are involved in and can support child emotion regulation. The findings of Study 1 suggest that in moments of negative child speaking turns, mothers who increased in RSA showed a higher proportion of affirming throughout their interaction with their child. This finding supports the study of parental parasympathetic regulatory response as an emotion-related socialization construct. However, mother RSA response was not associated with her proportion of affirming for mothers with a history of child maltreatment. This suggests that the physiological components that support emotion-related parenting behaviors might not function the same way within maltreating families, and additional study of dynamic physiology in small moments of interaction is warranted among families in maltreating contexts. Further, findings from Study 2 highlight the value of studying dyadic parasympathetic physiology as it relates to components of child prosocial emotion regulation, and suggest that parents and children whose RSA responses compensate for one another throughout a shared experience of negative emotion results in better prosocial situational responsiveness in children. In contrast to the interaction found in Study 1, the association between RSA synchrony and child prosocial situational responsiveness was only significant among children whose mothers showed a vulnerability in the form of a lower acceptance of their own emotions. Whereas an association between physiology and parent outcomes emerged in Study 1 only among those who were less vulnerable (based on child maltreatment status), an association between physiology and child outcomes emerged in Study 2 among those who were more vulnerable. While this could be due to
several reasons, e.g., the outcomes of interest were measured in parents compared to children while the source of both risk factors was the mothers, or perhaps child maltreatment is a risk factor of greater severity than maternal acceptance of emotions and thus physiology functions different across the two contexts, it highlights the need to study emotion-related dynamic physiological regulatory processes across a wide variety of contexts, with each individual finding interpreted within its given context.

Findings from both studies offer opportunities for practical application. For instance, building off of Study 1, future studies could examine the effectiveness with which parents can be trained to incorporate a wider range of emotion-supportive parenting practices into their repertoire of parenting behaviors, and if it is possible for the integration of certain self-regulatory techniques to result in a shift of parents’ parasympathetic responses in situations where certain responses might contribute to the escalation of negative affect as opposed to emotion-supportive parenting practices. For families with a history of child maltreatment, however, additional attention must be given to parenting practices and regulatory efforts that allow room for intervention, especially given that changing parenting practices of maltreating parents has proven especially difficult in the past (Skowron et al., 2011). Stemming from the findings of Study 2, evaluations of parent-child intervention programs could consider how the addition of dyadic physiological regulatory components might support greater gains in child prosocial emotion regulatory efforts. Additionally, given the interactive effect of maternal acceptance of own emotion with RSA synchrony, parent-child programs might also consider training specifically for parents around the acceptance of their own emotions and how parental beliefs surrounding emotions are communicated to their children.
Conclusion

These studies serve as an exciting initial investigation into the extensive possibilities of using dynamic parasympathetic physiology to study the contribution of parental and dyadic regulation to child emotion regulation skills and the parenting behaviors that support those skills. Whether it is during one particular moment of interaction with a child, or throughout the duration of an emotional shared experience, the study of individual and shared physiological regulation offers the opportunity to further understand the family processes that support the emotion regulatory skills children need to become independent emotion regulators and maintain positive social relationships throughout their lives.
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Appendix: Table of Studies Involving Parent-Child Cardiac Synchrony

<table>
<thead>
<tr>
<th>Reference</th>
<th>Participants</th>
<th>Cardiac Index</th>
<th>Synchrony Definition</th>
<th>Time Scale</th>
<th>Context/Task</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creaven et al. (2013)</td>
<td>104 Mother-child (3-5 years) dyads</td>
<td>HR RSA</td>
<td>Concordance: Mother HR/RSA predicted child HR/RSA</td>
<td>30-second epochs</td>
<td>Joint resting baseline</td>
<td>Among non-maltreating dyads, mom’s HR positively predicted child’s HR within 30-sec epochs. Nonsynchrony was observed in RSA.</td>
</tr>
<tr>
<td>Lunkenheimer et al. (2018)</td>
<td>47 Mother-child (M = 3.5 years) dyads</td>
<td>RSA</td>
<td>Concordance: mother RSA predicted child RSA and vice versa</td>
<td>30-second epochs</td>
<td>Joint free play, clean-up, and teaching tasks</td>
<td>Overall, mother RSA positively predicted child concurrent RSA and vice versa. Positive concordance was weaker during structured teaching task compared to other tasks. Higher maternal psychological aggression and higher child externalizing were associated with weaker positive concordance during the free play and cleanup tasks. Higher child internalizing was associated with weaker positive</td>
</tr>
</tbody>
</table>

Type of Synchrony Evidenced & Association with Parent-Child Outcomes, if Measured

Matched Nonsynchrony

Matched Compensatory Nonsynchrony
<table>
<thead>
<tr>
<th>Study</th>
<th>Sample Size</th>
<th>Measure</th>
<th>Coregulation: mother RSA predicted child RSA and vice versa</th>
<th>Epoch Duration</th>
<th>Task Description</th>
<th>Concordance/Dysynchrony</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lunkenheimer et al. (2015)</td>
<td>47 Mother-child (M = 3.5 years) dyads</td>
<td>RSA</td>
<td>Concordance during the free play task.</td>
<td>30-second epochs</td>
<td>Joint free play, clean-up, and teaching tasks For children low in externalizing behaviors, changes in mother RSA predicted changes in child RSA in the same direction and vice versa. For children high in externalizing behaviors, changes in mother RSA predicted changes in child RSA in the opposite direction, and vice versa.</td>
<td>Matched Compensatory</td>
</tr>
<tr>
<td>Suveg et al. (2016)</td>
<td>93 Mother-child (M = 3.5 years) dyads</td>
<td>IBI</td>
<td>Synchrony: Positive correlation in mother-child IBI</td>
<td>Second-by-second time series</td>
<td>Joint resting baseline; Joint interaction task (drawing on Etch-a-Sketch) Synchrony was found during the interaction but not baseline task. During the joint task, among high-risk families, greater physiological synchrony was correlated with lower behavioral synchrony (positivity, cooperation, empathic responding) and lower child self-regulation.</td>
<td>Matched: predictive of worse parent-child relationship and worse child outcomes in a risk context</td>
</tr>
<tr>
<td>Skoranski, Lunkenheimer, &amp; Lucas-Thompson (2017)</td>
<td>47 Mother-child (M = 3 years) dyads</td>
<td>RSA</td>
<td>Coregulation: mother RSA predicted child RSA and vice versa</td>
<td>30-second epochs; baseline was first part of Parent Child Challenge Task</td>
<td>Greater maternal teaching was related to greater time-dependent coregulation of mother-child RSA over time. Greater maternal disengagement was associated with weaker and divergent coregulation. Greater maternal baseline (non-resting baseline) was related to divergent coregulation in mother-child RSA over time. Positive concordance was found throughout the task.</td>
<td>Matched Compensatory Nonsynchrony</td>
</tr>
<tr>
<td>Study</td>
<td>Sample</td>
<td>Measure</td>
<td>Task/Epoch</td>
<td>Interaction Measure</td>
<td>Interaction Details</td>
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<td></td>
</tr>
<tr>
<td>Woltering et al.</td>
<td>118 Mother-child (7-12 years) dyads</td>
<td>IBI</td>
<td>2nd by 2nd</td>
<td>Conflict resolution task (positive topic, personal negative topic, another positive event)</td>
<td>Dyads were twice as likely to show synchrony during the last positive discussion compared to the first. These dyads exhibited higher levels of repair during interaction. During the negative discussion only, dyads who exhibited physiological synchrony displayed the greatest amount of behavioral synchrony. Matched: positive parent-child outcomes in a neutral context</td>
<td></td>
</tr>
<tr>
<td>Woody et al.</td>
<td>94 Mother-child (7-9 years) dyads</td>
<td>RSA</td>
<td>Task average; 30-second epochs</td>
<td>Positive and negative discussion tasks</td>
<td>When mothers who were depressed increased in RSA in a given 30-sec epoch, their children decreased in RSA. When mothers who were not depressed increased in RSA in a given 30-sec epoch, their children also increased in RSA. A negative association between mother and child RSA predicted higher baseline sadness in children and increases in sadness across the negative task for mothers. Matched Compensatory: worse child and mother outcomes in a parental-risk context</td>
<td></td>
</tr>
</tbody>
</table>
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