HHS Public Access
Author manuscript
J Child Psychol Psychiatry. Author manuscript; available in PMC 2017 November 10.

Published in final edited form as:
J Child Psychol Psychiatry. 2016 July ; 57(7): 843–850. doi:10.1111/jcpp.12562.

Synchrony of Physiological Activity during Mother-Child Interaction: Moderation by Maternal History of Major Depressive Disorder

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Abstract

Background—The family environment plays an important role in the intergenerational transmission of MDD, but less is known about how day-to-day mother-child interactions may be disrupted in families with a history of MDD. Disruptions in mother-child synchrony, the dynamic and convergent exchange of physiological and behavioral cues during interactions, may be one important risk factor. Although maternal MDD is associated with a lack of mother-child synchrony at the behavioral level, no studies have examined the impact of maternal MDD on physiological synchrony. Therefore, the current study examined whether maternal history of MDD moderates mother-child physiological synchrony (measured via RSA) during positive and negative discussions.

Method—Children ages 7–11 and mothers with either a history of MDD during the child's lifetime (n=44) or no lifetime diagnosis of any mood disorder (n=50) completed positive and negative discussion tasks while RSA was continuously recorded for both child and mother.

Results—Results indicated significant between-dyad and within-dyad group differences in physiological synchrony during positive and negative discussions. Between-dyad analyses revealed evidence of synchrony only among never depressed dyads, among whom higher average mother RSA during both discussions was associated with higher average child RSA. Within-dyad analyses revealed that never depressed dyads displayed positive synchrony (RSA concordance) whereas dyads with a history of maternal MDD displayed negative synchrony (RSA discordance) during the negative discussion and that the degree of negative synchrony exhibited during the negative discussion was associated with mothers' and children's levels of sadness.

Conclusions—These results provide preliminary evidence that physiological synchrony is disrupted in families with a history of maternal MDD and may be a potential risk factor for the intergenerational transmission of depression.

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Keywords

intergenerational transmission of depression; depression; mother-child interaction; respiratory sinus arrhythmia (RSA); synchrony

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Major depressive disorder (MDD) is a chronic and often recurrent psychiatric disorder that is associated with significant impairment in quality of life, productivity, and interpersonal functioning (American Psychiatric Association, 2000). Because of this, depressive disorders have been identified as a leading contributor to the global burden of disease (Ferrari et al., 2013) and the primary cause of disability worldwide (World Health Organization, 2012). Of particular concern, many individuals experience their first onset of depressive disorders during childhood or adolescence (with about 10% of all children meeting diagnostic criteria for MDD by age 16; Costello, Mustillo, Erkanli, Keeler, & Angold, 2003) and the onset of MDD during this period is associated with more severe impairment, a more chronic and recurrent course, and increased risk for suicide across the lifespan (Naicker, Galambos, Zeng, Senthilselvan, & Colman, 2013).

One of the most robust predictors of MDD risk in children is a family history of the disorder. For example, maternal history of major depressive disorder (MDD) during a child's life is known to contribute to significant impairment in the child's interpersonal, emotional, and academic functioning and greatly increases the child's own risk for MDD (Goodman, 2007). Individual differences in mother-child relationship quality contribute to risk for psychopathology (Ackard, Neumark-Sztainer, Story, & Perry, 2006), and the family environment plays an important role in the intergenerational transmission of depression (Gotlib & Colich, 2014). However, most previous research has focused on broad measures of mother-child relationship quality, such as global levels of warmth or criticism (Lovejoy, Graczyk, O'Hare, & Neuman, 2000), and much less research has focused on a fine-grained analysis of what occurs during actual mother-child interactions.

To begin to understand the link between parenting and child outcomes, we must look toward processes that contribute to positive versus negative mother-child interactions. One such process is synchrony, described as the dynamic exchange of physiological and behavioral cues between mothers and their children. Beginning in infancy, mothers and children respond to the specific cues of the other and then coordinate physiological and affective states (Feldman, 2012). When mother-child physiological responses occur in parallel, they are said to exhibit positive synchrony whereas discordant mother-child responses signify negative synchrony. Although positive synchrony is typically seen in healthy relationships, developmental scientists have suggested that mother-child synchrony is weakened by negative maternal influences such as depression (Feldman, 2012). Indeed, there is evidence that maternal depression is related to disruptions in mother-child synchrony at the behavioral level (e.g., Field, Healy, Goldstein, & Guthertz, 1990; Murray, Fiori-Cowley, Hooper, & Cooper, 1996; Radke-Yarrow, Nottelmann, Belmont, & Welsh, 1993). Although these studies provide promising initial evidence for disrupted synchrony as a risk factor for the intergenerational transmission of depression, synchrony at the behavioral level may be only one piece of the puzzle.

Notably, evidence from animal and infant-models suggests that physiological synchrony may be a protective factor that develops early in the mother-child relationship and promotes the child's physical and mental health (Feldman, 2007). However, very little research has examined mother-child physiological synchrony after infancy, and no studies of which we are aware of have examined physiological synchrony in children of depressed mothers. This said, several studies have shown that there is a significant correlation between mothers' and toddlers' cortisol reactivity to a laboratory-based challenge, but only among dyads with highly sensitive mothers and not among less sensitive mothers (Sethre-Hofstad, Stansbury, & Rice, 2002; van Bakel & Riksen-Walraven, 2008), suggesting that individual differences in mother-child relationship quality play an important role in physiological synchrony. Although these preliminary results are intriguing, studies examining cortisol response provide little information about the temporal course of synchrony because of the slow time-scale of cortisol responses. For example, a significant correlation in cortisol reactivity could indicate synchrony in physiological reactivity or it could reflect one member of the dyad having an early spike in reactivity and the other member of the dyad exhibiting a later increase in reaction to their family member's initial response. Therefore, a more temporally-sensitive measure is needed to provide a more fine-grained analysis of physiological synchrony.

Physiological measures of the autonomic nervous system (ANS) may be particularly well-suited to examine the temporal course of mother-child synchrony. Respiratory sinus arrhythmia (RSA; i.e., temporal variability in heart rate) is a peripheral measure of parasympathetic regulation and autonomic arousal in social contexts (Appelhans & Luecken, 2006; Porges, 2007). Increases in RSA are thought to support calm social engagement as the parasympathetic nervous system is activated. In contrast, decreases in RSA are thought to support defensive responses to social conflict as cardiac vagal control is withdrawn, allowing sympathetic activation to increase arousal states. In an early examination of RSA synchrony among mother-child dyads, one study provided evidence of a positive association between mother-child RSA during a challenge task but not at rest (Bornstein & Suess, 2000). A limitation of this study, however, is that it only examined synchrony using between-dyad associations (i.e., examining whether mothers who displayed higher average RSA across the entire rest period or challenge task had children who also had higher average RSA across the entire rest period or challenge task). Similar to the previously mentioned studies examining mother-child physiological synchrony via cortisol (Sethre-Hofstad et al., 2002; van Bakel & Riksen-Walraven, 2008), between-dyad analyses cannot provide information about the temporal course of synchrony and moment-to-moment changes in physiological activity.

To address these concerns, statisticians have suggested the use of within-dyad (or dynamic) analyses (McAssey, Helm, Hsieh, Sbarra, & Ferrer, 2011), which can be used to determine whether shifts in maternal RSA correspond to shifts in children's RSA and vice versa. An initial study using this approach examined within-dyad associations in mother-child RSA but found there were no significant between-dyad or within-dyad associations for mother-child RSA during rest (Creaven, Skowron, Hughes, Howard, & Loken, 2012). Although this study represents an important first step in determining whether RSA serves as an adequate measure of physiological synchrony within mother-child dyads, measuring mother-child RSA at rest may not provide a meaningful test of mother-child synchrony. Specifically, because synchrony is defined as the dynamic exchange of behavioral and physiological cues between members of a dyad, it is plausible that mothers and children must be actively engaged and interacting with one another to provide a meaningful measure of synchrony. Therefore, studies are needed that examine within-dyad RSA associations during mother-child interactions to provide a true test of physiological synchrony.

The present study was designed to address these statistical and methodological concerns as well as to determine whether physiological synchrony may be disrupted in families with a history of maternal MDD. Thus, the primary aims of the current study were to (i) examine synchrony of mother and child physiological response during interaction by collecting continuous measurements of RSA during a positive and negative discussion and (ii) determine if the presence of a maternal history of MDD moderates the level of physiological synchrony exhibited. We measured synchrony in two ways. First, we examined physiological synchrony using between-dyad analyses by examining correlations between average RSA levels in mothers and children during the positive and negative interactions (i.e., Do mothers who exhibit higher average RSA levels during a discussion have children who also exhibit higher average RSA across that discussion?). Second, we used within-dyad analyses to examine dynamic synchrony (i.e., At a moment to moment basis, do mothers and their children exhibit synchrony in dynamic changes in RSA across a discussion?). Across our two statistical models, we hypothesized that mother-child dyads with no history of maternal depression would exhibit positive synchrony (i.e., high concordance among average and dynamic mother-child RSA) during both the positive and negative discussions. In contrast, we hypothesized that dyads with a history of maternal depression during the child's life would display reduced or negative physiological synchrony (i.e., low concordance or even discordance among average and dynamic mother-child RSA) during positive and negative discussions. Finally, we examined the links between RSA synchrony and levels of sadness reported by mothers and children during the task. To the extent that reduced or negative RSA synchrony represents a potential risk factor for the intergenerational transmission of depression, it should be related to levels of sadness during the discussion paradigm.

Method

Participants

Participants in this study were 94 children ages 7–11 and their mothers recruited from the community. To be eligible for the current study, the child had to be biologically related to the participating mother and be living with that mother full-time. In addition, mothers were required to either meet criteria for a MDD episode during the child's lifetime (n =44) or have no lifetime diagnosis of any mood disorder (n = 50) according to the *Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition (DSM-IV*; American Psychiatric Association, 2000) Exclusion criteria for all mothers included current substance dependence and history of psychotic symptoms or bipolar disorder. For children in our sample, the average age was 9.09 years (SD = 1.43, Range = 7–11), 59% were male, and 76% were Caucasian. The average age of mothers in our sample was 36.24 years (SD = 6.60, Range = 25–52) and 85% were Caucasian. The median annual family income was $40,001–45,000.

Measures

The Structured Clinical Interview for *DSM-IV* Axis I Disorders (SCID-I; First, Spitzer, Gibbon, & Williams, 1994) was used to assess for lifetime *DSM-IV* Axis I disorders in mothers. As noted above, 44 mothers met criteria for MDD during their child's life. Inter-rater reliability studies within the laboratory have suggested excellent reliability for diagnoses of MDD (κ = 1.00).

Mothers and children also completed a standardized Discussion Paradigm, which included positive and negative interactions (Robin & Foster, 1989). Before the Discussion Paradigm, each mother and child separately completed an Issues Checklist, which lists several common topics of disagreement (homework, bedtime, chores, etc.) and were asked to endorse the frequency and intensity of their conflicts over each topic. Then, they completed the Discussion Paradigm. First, participants engaged in a 2-min rest period in which they watched a nature video featuring landscape scenes from Olympic National Park. Then, they completed a 4-min Vacation Planning task, for which they were asked to plan a "dream vacation" for the two of them. Following this conversation, the issue from the checklist that was mutually endorsed with the highest frequency and intensity ratings was be selected for a 6-min Issues Discussion, during which they were asked to talk about the issue, describe a recent disagreement, and attempt to come up with a resolution.

During each phase of the Discussion Paradigm, electrocardiogram (ECG) and respiration (RSP) data were obtained simultaneously for the mother and child using Biopac BioNomadix wireless systems and recorded with Acqknowledge v4.2 software. ECG was recorded via a standard 3-electrode (lead II) set-up and respiration was assessed with a respiratory belt around participants' chests. ECG and RSP data were sampled at 1000 Hz. MindWare HRV 3.0.12 was used to inspect, transform, and analyze the ECG and RSP signals. ECG data were visually inspected for artifacts (e.g., temporary equipment failure, large movements, or an unusual R-R interval), and artifacts were corrected manually. Epochs with more than 10% artifacts (i.e., 10% of R-waves estimated within an epoch) were excluded, and individuals with more than 50% missing epochs for any of the tasks (i.e., rest, vacation planning, or issues discussion tasks) were excluded from analyses.[1] To calculate RSA, spectral power analyses were performed with a fast Fourier transformation. Consistent with recommendations by the Task Force of the European Society of Cardiology and the North American Society of Pacing Electrophysiology (Camm et al., 1996), RSA was defined as power density in the .12–1.00 Hz frequency band for children and the .12 to .40 Hz band for adults and was calculated for each 30 s epoch of the 2-min rest period, 4-min Vacation Planning task, and 6-min Issues Discussion.

Finally, participants rated their sadness throughout the Discussion Task using a Visual Analog Scale (VAS). Specifically, mothers and children independently rated how they were feeling from "very happy" to "very sad" on a scale measuring 100 mm at three time points during the discussion task (following rest, vacation planning, and the issues discussion). To calculate VAS sadness scores, participants' ratings were measured from left to right on the

[1]Excluded dyads did not differ significantly from included dyads on any other study variables.

100 mm scale, and a sadness rating from 1 to 100 was recorded with higher numbers indicating greater state sadness.

Procedure

Upon arrival at the laboratory, mothers were asked to provide informed consent and children were asked to provide assent to be in the study. Following diagnostic interviewing and questionnaires, participants completed the Discussion Paradigm. As part of a larger study, mothers were compensated $80 and children received a $10 gift card to a local store. All study procedures were approved by the University's Institutional Review Board.

Results

Preliminary Analyses

Is maternal history of MDD related to participant demographic variables?—As shown in Table 1, there were no significant differences between children of depressed versus never depressed mothers in terms of age, sex, or race. In contrast, children of depressed mothers had, on average, lower family incomes than children of never depressed mothers. Importantly, however, family income was not related to children's or mothers' RSA during any phase of the study (lowest $p = .39$). In addition, none of the mother-child RSA synchrony results presented below were moderated by children's age, sex, race, or family income.

Do levels of sadness differ across task and dyad-member and is this moderated by maternal history of MDD?—Descriptive statistics for sadness ratings are presented in Table 2. To examine the impact of the Discussion Paradigm on state levels of sadness for mothers and children during each task, we conducted a 2 (Mother MDD history: yes, no) × 2 (Person: mother, child) × 3 (Task: rest, vacation planning, issues) repeated measures analysis of variance (ANOVA) with VAS sadness ratings following each task serving as the dependent variable. Results indicated significant main effects for Person, $F(1, 92) = 16.86$, $p < .001$, $\eta_p^2 = .16$, and Task, $F(2, 92) = 15.86$, $p < .001$, $\eta_p^2 = .15$, as well as a significant Person × Task interaction, $F(2, 92) = 5.88$, $p = .003$, $\eta_p^2 = .06$. The main effect of Mother MDD was not significant, and Mother MDD status did not significantly moderate the Person or Task effects (lowest $p = .27$).

To determine the form of the significant Person × Task interaction, we examined the Task main effect separately for each member of the dyad by conducting Bonferroni pairwise post-hoc comparisons. Among children, the main effect of Task was nonsignificant, $F(2, 92) = 2.79$, $p = .06$, $\eta_p^2 = .03$. Among mothers, the main effect of Task was significant, $F(2, 92) = 21.58$, $p < .001$, $\eta_p^2 = .19$, with mothers reporting lower sadness ratings during vacation planning ($M = 13.03$, $SE = 1.50$) than during rest ($M = 20.80$, $SE = 1.75$) or the issues discussion ($M = 26.11$, $SE = 2.21$) (both ps < .001). In contrast, mothers' reports of sadness during rest versus the issues discussion did not differ significantly ($p = .07$).

Do average RSA levels differ across task and dyad-member and is this moderated by maternal history of MDD?—Descriptive statistics for RSA levels are presented in Table 2. We examined the impact of the Discussion Paradigm on average RSA levels during each task for mothers and children by conducting a 2 (Mother MDD history: yes, no) × 2 (Person: mother, child) × 3 (Task: rest, vacation planning, issues) repeated measures ANOVA with average RSA values within each task for each person serving as the dependent variable. Results indicated significant main effects for Person, F(1, 92) = 67.81, *p* < .001, η_p^2 = .42, and Task, F(2, 92) = 4.85, *p* = .01, η_p^2 = .05, as well as a significant Person × Task interaction, F(2, 92) = 34.86, *p* < .001, η_p^2 = .28,. The main effect of Mother MDD was not significant, and Mother MDD status did not significantly moderate the Person or Task effects (lowest *p* = .28).

To determine the form of the significant Person × Task interaction, we examined the Task main effect separately for each member of the dyad by conducting Bonferroni pairwise post-hoc comparisons. Among children, there was a significant main effect of Task, *F*(2, 92) = 33.27, *p* < .001, η_p^2 = .27, with posthoc tests revealing significant differences between all three tasks (all *p*s < .001), such that children's RSA was highest during rest (*M* = 7.73, *SE* = .13), lower during vacation planning (*M* = 7.38, *SE* = .12), and even lower during the issues discussion (*M* = 7.20, *SE* = .11). Among mothers, there was also a significant main effect of Task, *F*(2, 92) = 7.25, *p* = .001, η_p^2 = .07, though the pattern differed from that observed in children. Specifically, mothers' RSA was significantly lower during rest (*M* = 6.08, *SE* = .13) than during vacation planning (*M* = 6.29, *SE* = .12) (*p* = .02) and the issues discussion (*M* = 6.31, *SE* = .12) (*p* = .01); however, RSA levels did not differ significantly between the vacation planning and issues discussions (*p* = 1.00).

Between-Dyad Synchrony Analyses

Do mothers who exhibit higher average RSA levels during a discussion have children who also exhibit higher average RSA during that discussion?—To examine between-dyad RSA synchrony, we examined correlations between average mother and child RSA levels during each of the two discussions in the Discussion Paradigm. Focusing on the sample as a whole, the mother-child correlations in average RSA level were not significant during vacation planning, *r* = .15, *p* = .14, or the issues discussion, *r* = .17, *p* = .11. However, when the never depressed and MDD groups were examined separately, we found significant positive mother-child correlations in RSA levels among the never depressed group during vacation planning, *r* = .40, *p* = .004, and the issues discussion, *r* = .41, *p* = .003. In contrast, these correlations were not significant in the MDD group during vacation planning, *r* = −.11, *p* = .46, or the issues discussion, *r* = −.07, *p* = .65. The group difference in the magnitudes of these correlations was significant for both the vacation planning, *z* = 2.50, *p* = .01, and issues discussion, *z* = 2.37, *p* = .02.

Within-Dyad Synchrony Analyses

Focusing next on within-dyad RSA synchrony, we used linear mixed models to examine dynamic synchrony within dyads separately for both the vacation planning and issues discussion tasks. For these analyses, children's RSA for each 30-sec epoch was entered as the dependent variable and Mother RSA at each 30-sec epoch, Mother MDD history, and their interaction were entered as predictor variables.[2]

At a moment-to-moment basis, do mothers and their children exhibit synchrony in dynamic changes in RSA across a discussion and is this moderated by maternal history of MDD?—We examined dynamic within-dyad synchrony during both the vacation planning and issues discussion. During the vacation planning task, the main effects of Mother MDD and Mother RSA, as well as the Mother RSA × Mother MDD interaction were all nonsignificant (lowest $p = .07$). During the issues discussion, the main effect of Mother MDD, $F(1, 613.86) = 3.24$, $p = .07$, and Mother RSA, $F(1, 903.90) = 0.09$, $p = .77$, were nonsignificant. However, there was a significant Mother RSA × Mother MDD interaction, $F(1, 903.90) = 6..87$, $p = .01$. Examining the form of this interaction, we found that, within the MDD group, higher RSA levels in mothers were associated with *lower* concurrent levels of RSA in children, $t(393.73) = -1.99$, $p = .048$, whereas in the never depressed group, higher RSA levels in mothers were associated with *higher* concurrent levels of RSA in children, $t(441.84) = 2.09$, $p = .04$.

Is mother or child state sadness correlated to mother-child synchrony?—To address this question, we calculated the within-dyad correlation in mother-child RSA for each discussion task and then examined the association of this measure of synchrony with mothers' and children's levels of baseline sadness as well as residual change in sadness from baseline to the end of that part of the Discussion paradigm. We found that the magnitude of negative RSA synchrony during the issues discussion was associated with higher baseline levels of sadness in children, $r = -.25$, $p = .02$, as well as greater increases in mothers' sadness from baseline to the end of that discussion, $r = -.20$, $p = .049$.

Discussion

The primary goal of this study was to examine physiological (i.e., RSA) synchrony in mother-child dyads during positive and negative discussions and to determine if the presence of a maternal history of MDD moderates physiological synchrony. In doing so, we tested between-dyad and within-dyad models of synchrony. We predicted that mother-child dyads with no history of mother MDD would exhibit positive physiological synchrony (i.e., high concordance in average and dynamic mother-child RSA) during both the positive and negative discussions and that mother-child dyads with a history of mother MDD would display reduced or negative physiological synchrony (i.e., low concordance or even discordance in average and dynamic mother-child RSA) during both discussions. Focusing first on our between-dyad analyses, we found that whereas mean RSA levels during each task were significantly and positively correlated among dyads with no maternal history of depression, the correlations were nonsignificant among dyads with a maternal history of MDD. As noted before, however, between-dyad analyses are unable to provide information about the temporal course of synchrony. Therefore, we also employed within-dyad (or dynamic) analyses to determine whether shifts in maternal RSA would correspond to shifts in children's RSA.

[2]For our within-dyad models, we re-ran our analyses using mother's RSA for each 30-sec epoch entered as the dependent variable, Child RSA at each 30-sec epoch entered as a covariate, and Mother MDD entered as a between subject factor. All of the significant effects regarding maternal history of MDD as a moderator of physiological synchrony were maintained regardless of whether mother or child RSA was included as the dependent variable.

During the negative discussion task, we found that mother-child dyads without a history of maternal depression displayed positive within-dyad synchrony during the negative discussion such that, at a moment-to-moment basis, mothers and their children exhibited congruent dynamic changes in RSA across the negative discussion. In contrast, among dyads with a maternal history of MDD, we found that mothers and their children displayed negative synchrony in dynamic changes in RSA across the negative discussion. That is, during the negative discussion, an increase in RSA in one member of the dyad was accompanied by a decrease in RSA in the other member, and vice versa. In contrast, during the positive discussion task, there was no evidence of within-dyad RSA synchrony among mother-child dyads in either group.

These findings raise an important question: Is negative physiological synchrony detrimental? To begin to answer this question, we examined the link between with-dyad synchrony and state levels of sadness among children and mothers. Intriguingly, we found evidence that the degree of negative synchrony exhibited during the negative discussion was associated with higher levels of children's state sadness at baseline and increases in mothers' state sadness during the negative discussion. That is, high levels of *negative* synchrony were associated with higher levels of sadness in children and mothers where as high levels of *positive* synchrony were associated with lower levels of sadness. These findings add to a growing body of research suggesting that depression weakens mother-child synchrony at a biological (e.g., Feldman, 2012) and behavioral level (e.g., Field et al., 1990; Murray et al., 1996; Radke-Yarrow et al., 1993). Although it is unclear at this time how physiological synchrony may be related to behavioral synchrony (e.g., vocal cues, facial expressions, verbal affirmations, etc.) among mother-child dyads with a history of maternal depression, animal and infant models of mother-offspring interaction have suggested a bi-directional relation between biological and behavioral synchrony such that both interact to modulate the development of essential neurobiological systems related to mood and social behavior (e.g., Feldman, 2012). Therefore, for children of mothers with a history of depression, it is likely that negative mother-child physiological synchrony contributes to poorer behavioral synchrony and vice versa, which then places the child at greater risk for reduced parent-child relationship quality and future depression. Future longitudinal work will be essential in determining the bi-directional link between mother-child physiological and behavioral synchrony and how they may underlie the intergenerational transmission of depression.

A second, related question that stems from our results inquires how one should interpret negative (discordant) physiological synchrony in the context of maternal-child interaction. By definition, negative physiology synchrony occurs when one member of the dyad displays increased RSA levels during interaction (RSA augmentation), which is associated with increased levels of calm social engagement, and the other partner displays decreased RSA levels (RSA suppression), which is associated with increased physiological arousal during social conflict. Intuitively, it may seem that negative physiological synchrony could be protective in some social scenarios. For example, if one member of a mother-child dyad begins to display increased physiological stress during an interaction, then it might make sense for the other member to decrease their level of physiological arousal to minimize negative affect and social conflict. However, recent studies have suggested that mothers and children who are able to flexibly and dynamically match one another's affective responses in positive *and* negative emotional contexts have lower internalizing symptoms and better relationship quality (e.g., Lougheed & Hollenstein, in press). Similarly, within the current study, although children of mothers with and without a history of depression did not differ from one another in their overall physiological and affective responses to the positive and negative discussion, they did differ in their likelihood to dynamically "match" their mothers' physiological response. Specifically, mother-child dyads with a history of maternal depression were significantly less likely to dynamically "match" their physiological response during a negative discussion whereas mother-child dyads with no maternal depression history did match physiological responses. In addition, similar to previous studies, mother-child dyads exhibiting the greatest physiological matching or synchrony also exhibited relatively lower levels of state sadness at baseline and within the negative discussion. Taken together, these findings contribute to the growing evidence of the protective nature of mother-child synchrony across affective, behavioral, and biological systems (see also Feldman, 2007; Lougheed & Hollenstein, in press)

The current study demonstrated several strengths including the first moment-to-moment assessment of mother-child interaction using physiological measures in dyads with a history of maternal depression and an examination of both between- and within-dyad models of physiological synchrony. Particularly, the juxtaposition of the study's between- and within-dyad analyses suggested that within-dyad analyses provide a more temporally-sensitive picture of mother-child physiological synchrony, consistent with the recommendations of previous researchers (McAssey et al., 2011). However, despite the strengths of our study, there were some limitations that highlight areas for future research. First, the design of our study was cross-sectional, which precludes any examination of how negative physiological synchrony may influence the future development of depression in high-risk children across time. Additional research is needed, therefore, to better understand the temporal relations among maternal depression, mother-child physiological synchrony, and children's risk for depression. In addition, our study only measured physiological synchrony using RSA. Future studies may benefit from the inclusion of multiple measures of physiology to better understand how physiology synchrony exists across neural, peripheral, and neuroendocrine systems. The inclusion of behavioral measures of synchrony would also be beneficial to determine if there is a directional relation between behavioral and physiological synchrony.

In summary, the current results provide evidence that physiological mother-child synchrony, which has been shown to be a protective factor in previous research with animals and humans (Feldman, 2007), is disrupted among families with a history of mother depression and is associated with mother and child levels of state sadness. If replicated and extended, these results could contribute to the development of clinical prevention and intervention programs that incorporate dyad-level biofeedback in addition to traditional family therapies to target both the behavioral and physiological aspects of the mother-child relationship. Although future research is needed to examine the precise role of mother-child physiological synchrony in the development of depressive disorders among children of depressed mothers, intervention and prevention programs such as these may play an important role in reducing risk for the development of depression among at-risk populations.

Acknowledgments

This research was supported by the National Institute of Mental Health grant MH098060 awarded to Dr. Gibb. We would like to thank Max Owens, Katie Burkhouse, Anastacia Kudinova, Aliona Tsypes, Sydney Meadows, Michael Van Wie, Devra Alper, Eric Funk, Nathan Hall, and Kiera James for their help in conducting assessments for this project as well as Jonathan Helm for statistical consultations regarding the within-dyad analyses.

Abbreviations

MDD	major depressive disorder
RSA	respiratory sinus arrhythmia

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Key Points

- Although children of mothers with a history of major depressive disorder (MDD) are at increased risk for depression, little is known about how day-to-day mother-child interaction may be disrupted in this at-risk group.
- This study focused on mother-child physiological synchrony, the dynamic exchange of physiological cues during positive and negative interactions, measured via respiratory sinus arrhythmia (RSA).
- Mother-child dyads with a maternal history of MDD displayed negative (discordant) physiological synchrony whereas never depressed dyads displayed positive (concordant) synchrony during interaction.
- The degree of negative synchrony exhibited during the negative discussion was associated with mothers' and children's levels of sadness.
- Disruptions in mother-child physiological synchrony may represent one risk factor for the intergenerational transmission of depression.

Table 1

Demographic Characteristics of Children

	Children of Depressed Mothers (*n* = 44)	Children of Never Depressed Mothers (*n* = 50)	t/χ^2
Age (*M*, *SD*)	8.89 (1.57)	9.26 (1.29)	1.26
Sex (% male)	61	56	0.28
Race (% Caucasian)	80	72	0.72
Family Income (median)	$50,001–$55,000	$30,001–$35,000	3.09 *

* $p < .01$.

Table 2

Descriptive Statistics for Levels of RSA and Sadness during the Discussion Paradigm as a Function of Maternal History of MDD

	Dyad with Mother Depression (*n* = 44)	**Dyads with No Mother Depression (*n* = 50)**
Rest		
Child RSA	7.64 (1.20)	7.82 (1.25)
Mother RSA	6.10 (1.32)	6.05 (1.24)
Child Sadness	14.09 (17.89)	15.10 (17.73)
Mother Sadness	21.88 (17.64)	19.71 (16.36)
Vacation Planning		
Child RSA	7.33 (1.10)	7.42 (1.11)
Mother RSA	6.39 (1.21)	6.18 (1.16)
Child Sadness	11.31 (15.29)	9.75 (15.54)
Mother Sadness	15.27 (17.91)	10.80 (10.59)
Issues		
Child RSA	7.09 (1.04)	7.32 (1.02)
Mother RSA	6.41 (1.19)	6.21 (1.14)
Child Sadness	13.25 (20.38)	16.51 (20.44)
Mother Sadness	26.80 (21.34)	25.43 (21.40)