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Depression impacts the physiological responsiveness of mother–daughter dyads during social interaction

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Abstract

Background—Maternal depression is associated with increased risk of psychiatric illness in offspring. While risk may relate to depressed mothers' difficulties regulating emotions in the context of interacting with offspring, physiological indicators of emotion regulation have rarely been examined during mother–child interactions—and never among mother–adolescent dyads in which both mother and adolescent have histories of major depressive disorder (MDD).

Methods—We examined changes in high-frequency heart rate variability (HF-HRV), an indicator of parasympathetic (vagal) function that has been related to depression, stress, social engagement, and emotion regulation, in 46 mother–daughter dyads (23 in which both mother and daughter had an MDD history and 23 never-depressed controls). Hierarchical linear models evaluated changes in HF-HRV while mother–daughter dyads engaged in discussions about shared pleasant events and relationship conflicts.

Results—While control dyads displayed positive slopes (increases) in HF-HRV during both discussions, MDD dyads displayed minimal change in HF-HRV across discussions. Among controls, HF-HRV slopes were positively correlated between mothers and daughters during the pleasant events' discussion. In contrast, HF-HRV slopes were *negatively* correlated between MDD mothers and daughters during both discussions.

Conclusions—Vagal responses observed in control mother–daughter dyads suggest a pattern of physiological synchrony and reciprocal positive social engagement, which may play a role in adolescent development of secure social attachments and healthy emotion regulation. In contrast, MDD mothers and daughters displayed diminished and discordant patterns of vagal responsiveness. More research is needed to understand the development and consequences of these patterns of parasympathetic responses among depressed mother–daughter dyads.

Keywords

biological markers; child/adolescent; depression; electrophysiology; maternal–child

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1 Introduction

Maternal depression places children at risk for negative outcomes including psychiatric illness, impaired social competence, and greater interpersonal stress (Hammen, Shih, & Brennan, 2004). Impairment in maternal interpersonal function may represent one mechanism by which maternal depression impacts child outcomes (Hammen et al., 2004). Depression adversely affects physiologic systems related to stress reactivity, emotion regulation, and social engagement (Libet & Lewinsohn, 1973), which may interfere with mothers' abilities to positively engage with, and sensitively respond to, children's emotional needs (Lovejoy, Graczyk, O'Hare, & Neuman, 2000). Such challenges are further complicated when both mother and child suffer from depression (Cyranowski, Swartz, Hofkens, & Frank, 2009). Thus, examination of physiological responsiveness during maternal–child interactions is needed to advance our understanding of, and ultimately inform targeted interventions for, depressed mother–child dyads.

Multiple theorists argue that parasympathetic control via the vagus nerve is central to regulating emotions during social interactions (Appelhans & Luecken, 2006; Beauchaine, 2001; Porges, 2001; Thayer & Lane, 2000). Part of the autonomic nervous system, the vagus nerve modulates moment-to-moment levels of parasympathetic control, acting as a brake on, and influencing beat-to-beat variations in, heart rate. The vagus nerve also modulates expression of emotions and receptivity of social engagement through its role in regulating the muscles that form facial expressions, eye gaze, vocalizations, and head orientation (Porges, 2003). The vagus enables individuals to flexibly adapt to changing environments by rapidly shifting autonomic balance in response to environmental cues (Cyranowski, Hofkens, Swartz, Salomon, & Gianaros, 2011), supporting prosocial behaviors in times of perceived safety or social affiliation (via vagal activation favoring parasympathetic dominance) and fight-or-flight responses during times of threat or stress (via vagal withdrawal; Porges, 2007).

Depressed individuals exhibit impairments in vagal function, including diminished levels of resting-state high-frequency heart rate variability (HF-HRV; Rottenberg, 2007), an indirect measure of vagal function, as well as blunted or dysregulated patterns of vagal responsiveness to environmental cues. Typically, positive mood inductions are accompanied by vagal activation (increases in HF-HRV), while acute stressors induce vagal withdrawal (decreases in HF-HRV). Consistent with the Emotion Context Insensitivity Theory, which posits that depressed individuals exhibit inflexible and restricted emotional responses to both positive and negative environmental cues (Rottenberg, Gross, & Gotlib, 2005), depressed individuals tend to exhibit less vagal activation, withdrawal, and overall fluctuation compared to controls in standard laboratory tasks (Bylsma, Salomon, Taylor-Clift, Morris, & Rottenberg, 2014; Cyranowski et al., 2011; Hughes & Stoney, 2000; Rottenberg, Clift, Bolden, & Salomon, 2007).

Such vagal dysfunction may negatively impact parenting among depressed mothers (Connell, Hughes-Scalise, Klostermann, & Azem, 2011). Relatively few studies have examined vagal responsiveness during mother–child interactions—especially in the context of depression. To date, most studies in this area have focused on maternal interactions with infants or young children (e.g., Calkins, Graziano, Berdan, Keane, & Degnan, 2008; Field, Pickens, Fox, Nawrocki, & Gonzalez, 1995; Woody, Feurer, Sosoo, Hastings, & Gibb, 2016). In contrast, examination of mother–adolescent interactions may be particularly important because adolescence represents a critical period for the development of interpersonal and emotion regulation skills, which are scaffolded through continued parent–child interactions (Smetana, Campione-Barr, & Metzger, 2006; Steinberg, 2005). The few studies to examine mother–adolescent interactions demonstrate that affect and behaviors during these interactions are linked to vagal function (Connell et al., 2011; Crowell et al., 2014; Woody et al., 2016). Yet no studies have explicitly compared vagal response patterns between depressed and nondepressed individuals during parent–adolescent interactions.

The primary aim of the present study was to examine vagal responsiveness among mother–adolescent daughter dyads with and without histories of major depressive disorder (MDD) during interaction tasks designed to elicit vagal activation and withdrawal. We focused on adolescent girls because the incidence of depression in offspring of depressed parents is highest for this subgroup (Weissman, Warner, Wickramaratne, Moreau, & Olfson, 1997). We hypothesized that compared to never-depressed control mothers and daughters, mothers and daughters with histories of MDD would show less vagal activation during a discussion of shared pleasant events and less vagal withdrawal during a discussion of interpersonal conflict.

In addition to individual patterns of vagal responsiveness, dynamic linkages in the physiologic responses of interacting mothers and daughters may be disrupted in the context of depression. Beginning in infancy, parent–child emotional interactions become temporally linked through a process referred to psychobiological attunement (Field, 1985), temporal interpersonal emotion systems (TIES; Butler, 2011, 2015), or biobehavioral synchrony (Feldman, 2007). The coordination of emotional communication between parents and children through such physiological processes as vagal responsiveness may provide the basis for children's development of secure attachment styles, adaptive relational behaviors, and emotional self-regulation (Gianino & Tronick, 1988). In depressed mothers and young children, these processes appear to be disrupted (e.g., Leclère et al., 2014; Woody et al., 2016), and such disruptions may represent one mechanism underlying the intergenerational transmission of depression risk. As a first step toward examining whether disruptions in biobehavioral synchrony may be present among depressed mother–adolescent dyads, exploratory analyses examined correlations in the slopes of mothers' and daughters' vagal responses over the course of both pleasant events and conflict interaction tasks.

2 Materials and Methods

2.1 Participants

Participants were 46 pairs of mothers (*M* = 46.95, *SD* = 5.05) and their adolescent daughters (*M* = 15.36, *SD* = 1.78). Twenty-three mother–daughter dyads in which both mother *and* daughter had a current or lifetime MDD diagnosis (MDD dyads) and 23 in which neither mother nor daughter had a history of MDD (control dyads) were enrolled. Demographic and clinical characteristics are presented in Tables 1 and 2. MDD dyads were recruited from various sources including community advertisements, child psychiatric treatment clinics, and a randomized control trial for depressed mothers of psychiatrically ill children (Swartz et al., 2016). Mothers recruited from the trial were permitted to enroll regardless of phase of study participation or current treatment status. All control dyads were recruited via community advertisements. Preliminary study eligibility was determined via a brief phone screen. Dyads were excluded if they were actively suicidal, suffering from a psychotic or bipolar disorder, taking medications that may interfere with heart rate, had an unstable medical condition, endorsed substance abuse within the preceding six months, or were not currently living together.

2.2 Procedure

All study procedures were approved by the University of Pittsburgh Biomedical Institutional Review Board. Mothers and daughters completed screening interviews to determine study eligibility. For the interaction tasks, mothers and daughters were seated across from each other and measurement equipment was attached. During a 10-min habituation period, they completed questionnaires. Next, participants rested quietly for a 6-min baseline period, then engaged in two 6-min interaction tasks (adapted from Whittle et al., 2009). Each task was preceded by a 2-min preparation period (not analyzed) and followed by a 6-min rest period.

2.3 Assessments

2.3.1 Clinical characteristics—Current and lifetime psychiatric diagnoses were ascertained by the Structured Clinical Interview for DSM-IV (First, Spitzer, Gibbon, & Williams, 1995) for mothers and the Kiddie Schedule for Affective Disorders and Schizophrenia (Kaufman et al., 1997) for daughters. Mothers and daughters reported current depressive symptoms on the 16-item Quick Inventory of Depressive Symptomatology (IDS; Rush et al., 2003) and the 27-item Children's Depression Inventory (CDI; Kovacs, 1992), respectively.

2.3.2 Interaction tasks—Personally relevant topics for discussions were chosen based on participants' responses to modified versions of the Pleasant Event Checklist (MacPhillamy & Lewinsohn, 1976) and the Issues Checklist (Prinz, Foster, Kent, & O'Leary, 1979). The former includes a list of activities families may enjoy together and the latter contains a list of topics on which parents and children often disagree. For the pleasant events task, participants (i) discussed an event they enjoyed together in the past, and (ii) planned a future pleasant activity, with each discussion lasting 3 min each. For the conflict task, participants discussed a topic that engendered mild-to-moderate conflict for 6 min. The pleasant events task was designed to elicit positive affect, prosocial behavior, and vagal activation; the conflict task was designed to elicit negative affect, conflictual behavior, and vagal withdrawal. To confirm the emotional impact of each interaction task, mothers and daughters completed adult and child versions of the Positive and Negative Affect Schedule (Laurent et al., 1999; Watson, Clark, & Tellegen, 1988) before and after each task.

2.3.3 Vagal responsiveness—Vagal responsiveness was measured via continuous ECG signals sampled at 1,000 Hz with three spot electrodes placed in a 3-lead configuration using MindWare BioNex data collection system (MindWare Technologies, Gahanna, OH). Using the MindWare HRV 2.16 software, R-wave markers in the ECG signal were processed with an artifact detection algorithm. Additional suspected artifacts were corrected manually. Spectral-power values were determined (in ms^2/Hz) with fast Fourier transformations, and power values in the 0.12–0.40 Hz spectral bandwidth were integrated (ms^2) as the indicator of HF-HRV for each minute.

2.4 Analysis plan

Two-level piecewise linear growth models were used to examine rates of change (i.e., slopes) in mothers' and daughters' HF-HRV during interaction and rest periods. At Level 1, participants' HF-HRV during task and rest periods were predicted by time in minutes, and at Level 2, slopes defined by Level 1 were predicted by individual-level characteristics (Kenny, Kashy, & Cook, 2006) including group (MDD versus control) and age, a known source of variance in HF-HRV (Antelmi et al., 2004; Hollenstein, McNeely, Eastabrook, Mackey, & Flynn, 2012). A *piecewise* linear growth model allows for the full growth trajectory to be broken into separate linear components to examine rates of change during single periods. This model was used to test our hypotheses that HF-HRV slopes would vary by task, such that the pleasant events discussion would elicit vagal activation (positive HF-HRV slope), while the conflict task would elicit vagal withdrawal (negative HF-HRV slope). Five slopes were modeled for each of the periods (i.e., baseline, pleasant events task, rest A, conflict task, rest B). Separate models were run for mothers and daughters. Equations are available in the supplementary material.

Exploratory analyses evaluated whether slopes of mothers' and daughters' HF-HRV were correlated during pleasant events and conflict discussion tasks. Parallel process growth models examined simultaneous change in dyads over time (Kenny et al., 2006). Correlations were obtained from models examining MDD and control dyads separately for each task (i.e., MDD dyads during pleasant events task, MDD dyads during conflict, control dyads during pleasant events task, control dyads during conflict).

3 Results

3.1 Demographic and clinical characteristics

Data from 43 mothers and 45 daughters were used in the main analyses. Two mothers were excluded for heart rate abnormalities (i.e., arrhythmia, potential premature ventricular contraction) and one mother and one daughter were excluded as outliers (z-values > 2.5; Stevens, 2012). No group differences were found for mothers or daughters on demographic variables (all ps >.05). Not surprisingly, MDD mothers and daughters reported higher levels of depressive symptoms compared to controls (all ps < .05). Five mothers (all MDD) and 12 daughters (11 MDD) met the threshold for probable current depression as evidenced by a score of 11 on the IDS and 12 on the CDI, respectively.

Eight MDD mothers and 10 MDD daughters reported taking antidepressants during the study. Analyses were run with and without these participants and patterns of responsiveness as well as effect sizes of group differences were similar (see supplementary material). Therefore, data from these participants were included in analyses.

3.2 Manipulation check

A series of dependent samples *t*-tests confirmed significant increases in self-reported positive affect following the pleasant events task, and significant increases in self-reported negative affect following the issues task, based on PANAS scores obtained from both mothers and daughters (all *p*s < 0.001).

3.3 Baseline

There were no group differences in initial (minute 1) HF-HRV values or baseline HF-HRV slopes in groups of mothers or daughters (*p*s > .05). For this reason, we did not control for these variables in the main analyses. For mothers, age was a significant predictor of the initial value ($p = .006$) and explained 15.2% of its variance. Age was not a significant predictor of the initial value for daughters.

3.4 Vagal responsiveness during interaction tasks and rest periods

Control mothers and daughters displayed positive HF-HRV slopes during both pleasant events and conflict tasks, and negative slopes during post-task rest periods. In contrast, MDD mothers and daughters showed little consistent change in HF-HRV during task and rest periods, as indicated by relatively flat trajectories depicted in Figure 1. See Table 3 for amount of change during each period and amount of variance explained by group. During the pleasant events task, there was a trend toward a depression group difference in slopes for mothers and daughters (*p*s < .08). During the conflict task, depression group significantly predicted slope for daughters ($p = .018$) but not for mothers ($p = .226$). For both mothers and daughters, depression group differences were found in slopes during rest periods following the interaction tasks (*p*s ≤ .051). For a visual representation of group differences in patterns of responsiveness, see Figure 1. See Tables 4–7 for model results.

3.5 Covariation in HF-HRV

Exploratory analyses included only dyads for whom data were available for both mother and daughter. For control dyads ($n = 23$), there was a very strong positive association ($r = .77$) between mothers' and daughters' slopes during the pleasant events task and no association during the conflict task ($r = .13$). For MDD dyads ($n = 19$), there was a moderate negative association between mothers' and daughters' slopes during the pleasant events task ($r = -.40$) and a strong negative association during the conflict task ($r = -.51$).

4 Discussion

To our knowledge, this is the first study to examine alterations in vagal responsiveness *during* social interactions in mothers and adolescents who both have histories of depression. As a group, never-depressed mothers and daughters displayed significant patterns of vagal activation during both social interaction tasks, indexed by positive slopes in HF-HRV (see Fig. 1). In contrast, MDD mothers and daughters displayed little consistent change in HF-HRV during the interaction tasks, suggesting that MDD dyads fail to mount a robust vagal response to these social interaction tasks. These results replicate and extend previous empirical evidence of "blunted" parasympathetic responses exhibited by depressed individuals to laboratory-based cues (Bylsma et al., 2014; Rottenberg et al., 2007). Because impairment in social relationships is common to depression (Segrin & Abramson, 1994), examination of vagal responsiveness during social interactions in depressed and non-depressed mother–child dyads constitutes an ecologically valid approach to examining these important issues.

Porges's polyvagal theory states that social affiliation, such as that elicited during a positive discussion between parent and child, should be associated with vagal activation. Lack of vagal activation in MDD dyads may suggest an inability to flexibly adjust physiological arousal to changing interpersonal demands. It may also suggest that these dyads were uncomfortable and/or not fully engaged with one another. For example, depressed individuals are more likely to report insecure (rather than secure) patterns of attachment in close relationships (Bifulco, Moran, Ball, & Bernazzani, 2002). Given depressed individuals' tendency to ruminate (Nolen-Hoeksema, 2000), it is also possible that MDD dyads were distracted by internal negative thoughts rather than fully engaged in the interactions, which may interfere with social engagement and effective interpersonal problem-solving (Lyubomirsky & Nolen-Hoeksema, 1995).

Surprisingly, control mothers and daughters also exhibited vagal activation during the conflict discussion. This result was unexpected given previous evidence of vagal withdrawal (indicative of a stress response) during conflict discussions among married couples (Smith et al., 2011). This inconsistency may relate to differences in conflict dynamics of parent–child versus adult romantic relationships, or in social desirability biases that may discourage mothers from engaging in heated arguments with children in public. The conflict topics chosen in this study (e.g., cleaning the child's room, fighting with siblings) may also have been less threatening than those typically selected by romantic partners (e.g., finances). In fact, to minimize the possibility of triggering extreme distress, experimenters instructed mothers and daughters to select topics that were moderately (but not severely) distressing.

Results also showed alterations in patterns of mother–child synchrony in vagal responses to social interactions among MDD, relative to control, dyads. Among control dyads, mothers and daughters displayed strong, positive correlations in their patterns of vagal activation during the pleasant events task. We speculate that these linked vagal activation slopes may indicate adaptive patterns of biobehavioral synchrony in control mothers and daughters. In contrast, MDD dyads displayed *negative* correlations in slopes of HF-HRV during both the pleasant events and conflict discussions. These negative correlations indicate that within individual mother–daughter MDD dyads, as one partner increased in HF-HRV, the other partner decreased (and vice versa). This finding also suggests that while *group-level* analyses indicate a blunted vagal response among MDD dyads, the negative associations observed in slopes of individual mother–daughter dyads suggest that some individual variability in vagal response is present and negatively linked to the partner's response pattern.

These results are partially consistent with a recent study of physiological synchrony in mothers with MDD history and their 7- to 11-year-old children (Woody et al., 2016). In this study, mothers with MDD history displayed discordant (negatively associated) moment-to-moment HF-HRV responses with their children's HF-HRV responses, while never-depressed mothers displayed concordant (positively associated) responses with their children's responses, as observed during a conflict discussion. In contrast to our findings, however, these researchers found no association in HF-HRV between never-depressed mothers and children during a positive, vacation-planning discussion. Future research is needed to better understand the parameters and implications of the lack of physiological synchrony observed in depressed mother–child dyads.

The inability to simultaneously control for changes in respiration limits studies of vagal responsiveness during social interactions. Although control for respiration during examination of vagal responsiveness is common (because of known influence of respiration rate on HF-HRV), reliable measurement of respiration changes during speech is difficult. Bernardi and colleagues (2000) found that free speech decreased respiration, increasing low-frequency power and decreasing high-frequency power in *RR* interval, which may lead to exaggerated observations of parasympathetic withdrawal during speech. In the present study, however, vagal *activation* was exhibited in control dyads during both discussion tasks. Moreover, we posit that differences in vagal responses observed between MDD and control dyads in the current study are unlikely to be solely an artifact of speaking-related respiratory factors.

Our study is also limited by the small sample size. A larger sample would have allowed us to utilize more advanced statistical methods to examine dyadic synchrony, such as a multilevel structural equation modeling framework that would allow for more-flexible cross-dyad associations (Bolger & Laurenceau, 2013). Future research with larger samples is also needed to simultaneously model additional factors that may impact vagal responsiveness, such as attachment security (Diamond & Hicks, 2005) and trauma history (Cyranowski et al., 2011). Moreover, the current study design (which did not include dyads in which only one partner had a history of depression) cannot tease out the extent to which observed patterns of vagal dysfunction were driven by the actor's or the partner's depression history. Results of this study cannot be generalized to males because our sample included only females. Finally, a subset of participants were taking antidepressants, which may be associated with diminished resting-state HF-HRV levels (Kemp et al., 2010). When these participants were removed from analyses, however, patterns of vagal responsiveness were unchanged. To our knowledge, no previous studies have examined effects of antidepressants on vagal responsiveness. It will be important for future studies to address these limitations.

This study has several potential clinical implications for furthering our understanding of the intergenerational transmission of depression. Lack of consistent vagal activation observed among mothers with MDD history may help to elucidate parenting difficulties depressed mothers face when trying to interact with their children in a warm, positive, and sensitive manner. In addition, disruptions in mother–child physiological synchrony may impact adolescent daughters' abilities to develop positive, secure attachment relationships and healthy emotion-regulation skills. To better understand the broader influence of such physiological dysregulation, future work will also need to examine associations of physiological responses with behavioral and affective components of these social interactions. For example, Crowell et al. (2014) found that during a conflict discussion, depressed adolescents became physiologically and behaviorally dysregulated simultaneously.

5 Conclusion

Our results are consistent with studies demonstrating that depressed mothers experience interpersonal impairments when interacting with their children (Lovejoy et al., 2000), which may contribute to the negative outcomes observed in offspring of depressed parents (Weissman et al., 2006). Considering the importance of interpersonal factors in the onset and maintenance of depression, one area for intervention may include treating mothers and children in *pairs*, with a focus on improving positive social engagement and communication. Given the high concordance of vagal activation observed among control dyads during the pleasant events task, treatment strategies aimed at eliciting and sustaining mutually positive emotional interactions may benefit dyads with MDD history. Indeed, greater positive concordance has been shown to be important for the socialization of emotions within families as well as the development of supportive parent–child relationships (Criss, Shaw, & Ingoldsby, 2003). A better understanding of physiologic processes in parent–child interactions may inform both mechanistic studies of reciprocal effects between mother–child relationships and outcomes in high-risk families, as well as development of targeted treatment approaches focused on enhancing adaptive physiologic responsiveness to interpersonal cues.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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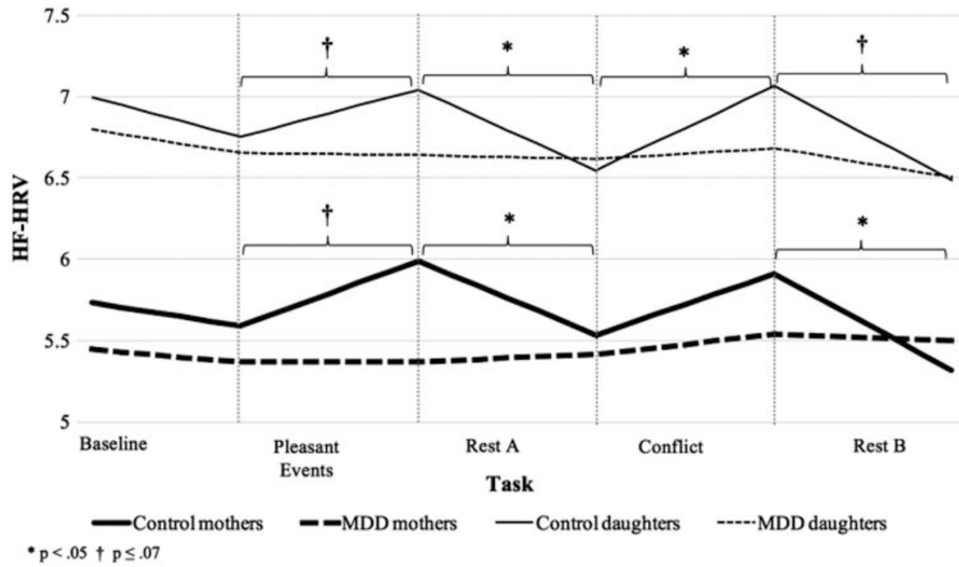

Figure 1. HF-HRV of mothers and daughters

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Table 1

Demographic and clinical characteristics of mothers

Characteristic		Overall (N = 43)	Control (N = 23)	History of Depression (N = 20)	Statistic
Age	M (SD)	46.95 (5.05)	47.33 (4.40)	46.50 (5.78)	t = 0.53, p = .597
Race					χ^2 = 1.18, p = .554
Caucasian	n (%)	33 (76.7)	18 (78.3)	15 (75.0)	
African American	n (%)	9 (20.9)	5 (21.7)	4 (20.0)	
Mixed/other	n (%)	1 (2.3)	0 (0.0)	1 (5.0)	
Education					χ^2 = 8.98, p = .062
High school diploma/GED	n (%)	4 (9.3)	1 (4.3)	3 (15.0)	
Partial/Full undergraduate	n (%)	26 (60.5)	11 (47.8)	15 (75.0)	
Graduate degree	n (%)	13 (30.2)	11 (47.8)	2 (10.0)	
Income					χ^2 = 14.67, p = .100
Less than $10,000	n (%)	1 (2.3)	0 (0.0)	1 (5.0)	
$10,000-$29,999	n (%)	8 (18.6)	1 (4.3)	7 (35.0)	
$30,000-$74,999	n (%)	14 (32.6)	8 (34.7)	6 (30.0)	
Greater than $75,000	n (%)	20 (46.5)	14 (60.9)	6 (30.0)	
Marital status					χ^2 = 4.92, p = .426
Married/living with partner	n (%)	28 (65.1)	17 (73.9)	11 (55.0)	
Never married	n (%)	5 (11.6)	2 (8.7)	3 (15.0)	
Separated/divorced	n (%)	9 (20.9)	3 (13.0)	6 (30.0)	
Widowed	n (%)	1 (2.3)	1 (4.3)	0 (0.0)	
Current smokers	n (%)	7 (16.3)	3 (13.0)	4 (20.0)	χ^2 = 0.09, p = .538
BMI	M (SD)	29.97 (7.24)	28.90 (7.07)	31.14 (7.42)	t = −1.00, p = .322
IDS-16	M (SD)	4.56 (4.15)	2.52 (1.31)	6.90 (5.04)	t = −3.78, p = .001

Table 2

Demographic and clinical characteristics of daughters

Characteristic		Overall (N = 45)	Control (N = 25)	History of Depression (N = 20)	Statistic
Age	*M* (*SD*)	15.36 (1.78)	14.96 (1.69)	15.86 (1.81)	$t = -1.72$, $p = .093$
CDI	*M* (*SD*)	8.93 (9.74)	3.32 (3.47)	15.95 (10.54)	$t = -5.14$, $p = .000$

Table 3

Change in HF-HRV, amount of variance explained by group, and effect size of group during each period

		Change in HF-HRV			
Period	**Participant Type**	**Controls**	**History of Depression**	**Proportion of Variance**	***d***
Baseline	Mothers	−0.14	−0.08	0%	.09
	Daughters	−0.24	−0.14	n/a	.04
Pleasant events task	Mothers	0.39	0.00	15%	.60†
	Daughters	0.29	−0.01	14%	.56†
Rest A	Mothers	−0.45	0.04	28%	.80*
	Daughters	−0.49	−0.02	43%	.92*
Conflict task	Mothers	0.37	0.13	7%	.38
	Daughters	0.43	0.06	23%	.75*
Rest B	Mothers	−0.59	−0.04	19%	.70*
	Daughters	−0.58	−0.18	21%	.61†

Note: Due to a lack of significant variability in slopes during baseline for daughters, random effects were not estimated during this period.

*Group difference $p < .05$.

†Group difference $p \leq .07$.

Table 4

Mothers: HF-HRV fixed effects

Fixed Effect	Symbol	Coefficient	*SE*	*t*-Ratio	*df*	*p*
Initial status	π_0					
Control	β_{00}	5.731	0.241	23.759	40	< 0.001
MDD	β_{01}	−0.286	0.354	−2.916	40	0.423
Mother's age	β_{02}	−0.075	0.026	−0.809	40	0.006
Baseline slope	π_{01}					
Control	β_{10}	−0.028	0.030	−0.936	41	0.355
MDD	β_{11}	0.012	0.043	0.286	41	0.776
Pleasant events task slope	π_2					
Control	β_{20}	0.066	0.023	2.839	41	0.007
MDD	β_{21}	−0.065	0.034	−1.910	41	0.063
Rest A slope	π_3					
Control	β_{30}	−0.075	0.022	−3.477	41	0.001
MDD	β_{31}	0.082	0.032	2.570	41	0.014
Conflict task slope	π_4					
Control	β_{40}	0.062	0.023	2.747	41	0.009
MDD	β_{41}	−0.041	0.033	−1.228	41	0.226
Rest B slope	π_5					
Control	β_{50}	−0.098	0.028	−3.507	41	0.001
MDD	β_{51}	0.091	0.041	2.234	41	0.031

Table 5

Mothers: HF-HRV random effects

Random Effect	Symbol	*SD*	Variance Component	*df*	χ^2	*p*
Initial status	r_0	1.082	1.172	40	3494.493	< 0.001
Baseline slope	r_1	0.080	0.006	41	62.667	0.016
Pleasant events task slope	r_2	0.073	0.005	41	74.158	0.001
Rest A slope	r_3	0.065	0.004	41	71.445	0.003
Conflict task slope	r_4	0.072	0.005	41	77.010	<0.001
Rest B slope	r_5	0.094	0.009	41	85.835	<0.001
Level 1 error	*e*	0.575	0.330			

Table 6

Daughters: HF-HRV fixed effects

Fixed Effect	Symbol	Coefficient	*SE*	*t*-Ratio	*df*	*p*
Initial status	π_0					
Control	β_{00}	6.994	0.176	39.824	42	< 0.001
MDD	β_{01}	−0.196	0.267	−0.735	42	0.466
Daughter's Age	β_{02}	−0.087	0.064	−1.364	42	0.180
Baseline slope	π_{01}					
Control	β_{10}	−0.048	0.022	−2.179	1117	0.030
MDD	β_{11}	0.019	0.033	0.586	1117	0.558
Pleasant events task slope	π_2					
Control	β_{20}	0.048	0.018	2.663	43	0.011
MDD	β_{21}	−0.050	0.027	−1.850	43	0.071
Rest A slope	π_3					
Control	β_{30}	−0.082	0.017	−4.758	43	< 0.001
MDD	β_{31}	0.079	0.026	3.009	43	0.004
Conflict task slope	π_4					
Control	β_{40}	0.086	0.020	4.220	43	<0.001
MDD	β_{41}	−0.076	0.031	−2.462	43	0.018
Rest B slope	π_5					
Control	β_{50}	−0.097	0.022	−4.321	43	< 0.001
MDD	β_{51}	0.067	0.033	2.012	43	0.051

Table 7

Daughters: HF-HRV random effects

Random Effect	Symbol	*SD*	Variance Component	*df*	χ^2	*p*
Initial status	r_0	0.781	0.609	42	723.298	< 0.001
Pleasant events task slope	r_2	0.045	0.002	43	67.356	0.010
Rest A slope	r_3	0.042	0.002	43	58.177	0.061
Conflict task slope	r_4	0.068	0.005	43	79.984	<0.001
Rest B slope	r_5	0.067	0.005	43	70.566	0.005
Level-1 error	e	0.542	0.293			