Dynamic Changes in Parent Affect and Adolescent Cardiac Vagal Regulation: A Real-Time Analysis

ARTICLE in JOURNAL OF FAMILY PSYCHOLOGY · MARCH 2015
Impact Factor: 1.89 · DOI: 10.1037/fam0000067

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Dynamic Changes in Parent Affect and Adolescent Cardiac Vagal Regulation: A Real-Time Analysis

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The current study explored the role of parents’ negative and positive affect in adolescent respiratory sinus arrhythmia (RSA) reactivity during a parent-adolescent conflict discussion task and the moderating effects of adolescent sex and age. Questionnaire data were collected from 206 adolescents (10–18 years of age; M = 13.37 years) and their primary caregivers (83.3% biological mothers). Electrocardiogram and respiration data were collected from adolescents, and RSA variables were computed. Parent affect was coded during the conflict discussion task. Multilevel modeling was used to distinguish the between- and within-individual effects of parent affect on adolescent RSA. Results indicated that observed within-parent–teen dyad anger was negatively associated with adolescent RSA, controlling for previous-minute RSA level, particularly among adolescents 13 years and older. In addition, observed between-dyad positive affect was positively linked to RSA for both boys and girls when previous-minute RSA level was controlled. Within-dyad positive affect was positively related to girl’s RSA only. These findings suggest that expressions of positive affect may be related to better vagal regulation (RSA increases), whereas expressions of anger may be related to poor vagal regulation (RSA decreases) during social engagement.

Keywords: respiratory sinus arrhythmia, parent affect, multilevel modeling, affect dynamic, adolescence

Over the last several decades, developmental research on parenting has begun to focus on the role of biology in promoting and understanding parent–child relationships and children’s socioemotional development (e.g., Connell, Hughes-Scalise, Klostermann, & Azem, 2011; Morris, Cui, & Steinberg, 2013). Recently, researchers have begun to examine factors that influence children’s parasympathetic and sympathetic responses to stress (e.g., Hastings et al., 2008; Katz & Rigterink, 2012), often examining respiratory sinus arrhythmia (RSA) as an indicator of that response. Indeed, RSA baseline and reactivity patterns have been associated with child and adolescent internalizing and externalizing problems (e.g., Beauchaine, 2001; Gentzler, Santucci, Kovacs, & Fox, 2009), and studies have found that negative contextual factors such as adverse parent–child relationships tend to dampen RSA baseline and reactivity to challenge (e.g., Burgess, Marshall, Rubin, & Fox, 2003; Hastings et al., 2008; Katz & Rigterink, 2012). Nevertheless, relatively few studies have investigated RSA reactivity during ecologically valid social interaction tasks, such as a parent–adolescent conversation about conflict. Moreover, few studies have tapped into how parenting contributes to parasympathetic or vagal regulation among adolescents in such contexts.

According to polyvagal theory, RSA reactivity during social engagement reflects one’s ability (not just potential) to regulate attention and emotion (i.e., cardiac vagal regulation; Porges, 2007, 2011). To our knowledge, there have been no published studies that have directly examined RSA reactivity during social engagement and how subtle changes in parent affect (i.e., within-parent–teen dyad effects) may contribute to adolescent RSA reactivity. In response, the current study focused on parent affect during a mildly stressful social engagement activity (i.e., a parent–adolescent conflict discussion task) and analyzed how parent affect was related to adolescent RSA levels during the task. Specifically, we tested the relations between within- and between-dyad negative and positive affect and adolescent RSA reactivity in real time. We also explored the possible moderating effects of adolescent sex and age in these associations.

Vagal control of the heart modulated by the myelinated vagus is posited to facilitate social communication and engagement (Porges, 2007, 2011). Cardiac vagal control or regulation has often been measured by RSA, which is defined as “a rhythmical fluctuation in heart periods at the respiratory frequency that is characterized by a shortening and lengthening of heart periods in a phase relationship with inspiration and expiration, respectively” (Bernston, Cacioppo, & Quigley, 1993, p. 183). Empirical studies of...
parasympathetic nervous system functioning typically focus on RSA baseline and RSA reactivity. RSA levels assessed during a resting state are often called RSA baseline (i.e., one’s potential to focus attention, engage in social communication, and maintain homeostasis; Porges, 2007). Changes in RSA levels from a resting or baseline state are often called RSA reactivity, which includes RSA suppression (decreases from baseline) and sometimes RSA augmentation or recovery (increases from baseline). In the current study, we focused on RSA reactivity during a social engagement activity (i.e., a conflict discussion task). This task is ecologically valid and thought to reflect how parents and adolescents typically discuss and solve disagreements in daily life, and it has been used in various parenting studies (e.g., Connell et al., 2011; Eisenberg et al., 2008).

Parenting and Autonomic Nervous System Functioning

There is an increasing body of literature suggesting that family context may shape children’s brain development, pubertal timing, and the expression of genes (e.g., Blair & Raver, 2012; Steinberg et al., 2006). Contextual factors, particularly parenting, are also posited to influence autonomic nervous system (ANS) functioning in a variety of ways. Normally, children show increases in baseline RSA from preschool to middle childhood (Bornstein & Suess, 2000; Calkins & Keane, 2004; Quas, Hong, Alkon, & Boyce, 2000; Rigterink, Katz, & Hessler, 2010) and maintain stable RSA baseline from late childhood to early adolescence (El-Sheikh, 2005b). However, adverse experiences within the family system (e.g., marital discord, negative parenting) have been found to relate to less gain in RSA baseline by middle childhood (Katz & Rigterink, 2012; Rigterink et al., 2010). Moreover, research has found that, compared with low levels of observed critical/negative parenting, high levels of observed maternal negative parenting were related to smaller RSA increases in a socially challenging context (Hastings et al., 2008). Although a growing body of literature suggests that negative parenting is related to low baseline RSA, less is known about the underlying mechanisms of how adverse family experiences or negative parenting lead to deficits in cardiac vagal regulation during social interactions. We argue that one mechanism through which this may occur is through the emotional climate that parenting behaviors generate.

In general, parenting can influence children’s parasympathetic or cardiac vagal regulation in a variety of ways. Parents can create and maintain a warm, supportive, and consistent family environment that facilitates self-regulation, or parents can create a hostile, coercive, and unpredictable family environment that facilitates reactivity, arousal, and low regulation (Cui, Morris, Criss, Houltberg, & Silk, 2014; Morris, Silk, Steinberg, Myers, & Robinson, 2007). In addition, parents may shape their children’s regulatory skills through their own expression and regulation of emotions (e.g., Buckholdt, Parra, & Joe-Shields, 2014; Fosco & Grych, 2013; Jaser et al., 2008; Kim, Pears, Capaldi, & Owen, 2009). For example, among 8–10-year-olds, Fosco and Grych found that high parental negativity and low-year-olds (e.g., displays of negative and positive emotions) were significantly related to poor child emotion regulation. Moreover, Jaser et al. reported that maternal sadness was negatively related to adolescent effective emotion coping and positively associated with physiological arousal to stress and maladaptive regulation strategies (e.g., rumination).

Similarly, during a parent–adolescent problem-solving task, above and beyond coded overall parent anger (combined mother and father anger), high maternal anger (within mothers) was related to high adolescent anger and heart rate during interactions (Jackson, Kupens, Sheeber, & Allen, 2011), suggesting adolescent heighted physiological responses to parent anger. In the current study, we extended the literature by focusing on parent negative (i.e., anger and distress) and positive affect and analyzed the relations between parent affect and adolescent RSA reactivity, which is thought to be a pure measure of cardiac vagal regulation (Porges, 1995, 2011).

**RSA Baseline and Reactivity and Social Contexts**

RSA baseline reflects one’s potential for physiological regulation of inner resources in response to challenge and ability to engage in social activities (Porges, 2007). Empirical studies have found that high levels of baseline RSA are related to good self-regulation and low levels of aggressive behaviors and depression (e.g., Beauchaine, Hong, & Marsh, 2008; Chapman, Woltering, Lamm, & Lewis, 2010; Crowell et al., 2005; El-Sheikh & Hinnant, 2011; Vögele, Sorg, Studdmann, & Weber, 2010). RSA suppression in response to stressful contexts indicates the readiness to respond to environmental threats, whereas RSA augmentation facilitates the maintenance of equilibrium and social engagement (Brooker & Buss, 2010; Porges, 2007). Mixed results have emerged regarding the associations between RSA reactivity and behavior problems (for a review, see Hastings & Miller, 2014). For example, RSA suppression has been related to fewer behavior problems and better emotion regulation (e.g., El-Sheikh & Hinnant, 2011; Gentzler et al., 2009; for a review, see Graziano & Derefinko, 2013). Other studies have either found null results (e.g., Eisenberg et al., 2012; Quas et al., 2000) or contradictory results (e.g., Hastings et al., 2008; Quas, Carrick, Alkon, Goldstein, & Boyce, 2006).

When empirical results are taken together, RSA reactivity appears to be much more complex than RSA baseline, and its interpretation may differ across studies. Because different types of laboratory-based challenging tasks (e.g., physical, cognitive, social, emotional) with varying levels of stress have been used in previous studies, we argue that different stressors might evoke different levels of social and attentional vigilance and therefore alter affective states differentially (see also Bornstein & Suess, 2000; El-Sheikh, 2005a, 2005b). Moreover, RSA reactivity observed in previous studies may have corresponded to varying stress levels within different external contexts, and its link to developmental outcomes should be interpreted in the specific context of RSA measurement. In highly stressful contexts such as watching an intensive emotional film clip or a public speech, observed RSA suppression might indicate an individual’s physiological responses to the challenge and readiness to cope with the stress, which in turn may lead to better emotion and behavioral outcomes. Low RSA levels or RSA suppression may signify the readiness to respond to internal or external threats or challenges in the environment (Porges, 1995, 2007, 2011), and subsequent RSA recovery after the threats are removed may suggest vagal regulation efforts. Indeed, recent studies have taken the context of RSA measurement into account and used a temporal approach to analyze RSA reactivity across time. This research has shown RSA suppression
followed by subsequent RSA recovery to be linked to better emotion regulation, more prosocial behavior, and low aggression (e.g., Brooker & Buss, 2010; Cui et al., 2015; Miller et al., 2013). In mildly stressful contexts (e.g., social interview, parent–adolescent discussion of daily issues), however, it is more adaptive to maintain high levels of RSA, which reflect an individual’s active regulation to facilitate social engagement and communication (Porges, 2003, 2007, 2011). Given the evidence that associations between RSA and emotion processes may be more robust in social situations (Butler, Wilhelm, & Gross, 2006), we argue that RSA is best understood in the context of social engagement.

**RSA Reactivity and Social Engagement**

Social engagement behaviors include listening to conversations and showing related facial expressions and body movements, which are supported by the myelinated vagus of the ANS (Porges, 2011). The integrated neural and biological systems supporting social engagement behaviors are called the social engagement system, and deficits in this system may dampen children’s bonding with parents or attachment to parent figures (Porges, 2003, 2011), which in turn may lead to poor child outcomes. RSA, a pure measure of myelinated vagal functioning, is a good representation of parasympathetic or cardiac vagal regulation abilities, particularly during social interactions. According to polyvagal theory and empirical studies mentioned earlier, RSA augmentation or maintenance (i.e., maintaining high levels of RSA) during social engagement may reflect good vagal regulation ability, which is thought to facilitate the maintenance of an internal equilibrium and social engagement, also indicating a safe environment. However, when one perceives the environment to be safe, usually during regular daily social communication, low RSA levels across time or RSA suppression from a previous state (after environmental challenges disappear) may represent poor attention and emotion dysregulation (Porges, 2011).

To our knowledge, there have been few published studies that directly tested RSA dynamics during social interactions (Butler et al., 2006; Connell et al., 2011). In traditional RSA studies, for example, participants have been passively exposed to lab stressors such as physical (e.g., receiving special stimuli such as lemonade on the tongue), cognitive (e.g., tracing stars), or emotional (e.g., watching film clips) challenges (e.g., Obradović, Bush, Stampedahl, Adler, & Boyce, 2010). None of these laboratory tasks closely reflect real-life situations. Moreover, according to polyvagal theory, social interaction is a critical setting for studying cardiac vagal regulation (Butler et al., 2006; Porges, 2011). Thus, in response to this research gap in understanding RSA functioning in social communication and engagement, we used the ecologically valid conflict discussion task and focused on RSA changes in real time.

**The Current Study**

In summary, the current study addressed the following issues. First, we investigated the link between minute-to-minute parent affect (observed anger, distress, and positive affect) and minute-to-minute adolescent RSA reactivity during the parent–adolescent conflict discussion task. Second, we analyzed whether these links varied by adolescent age and sex. Discussion of conflict is mildly stressful for most youths (Connell et al., 2011; Eisenberg et al., 2008) and requires active processing (i.e., allostatics) as a youth has to constantly modulate internal resources (e.g., attention focusing); the myelinated vagus supports this processing in accordance with the constantly changing context (e.g., parents’ changing affect). Thus, we expected to observe adolescents maintaining relatively high levels of RSA during the task. In all analyses, we statistically controlled for respiration rate because talking and dramatic physical movements, which alter respiration, may seriously confound RSA measurement (Berntson, Quigley, & Lozano, 2007; Porges et al., 2007; Ritz, 2009), particularly during social interaction tasks (Butler et al., 2006). Theoretically, we expected that parents’ displays of negative affect (i.e., anger and distress) would be related to adolescent RSA decreases (i.e., poor cardiac vagal regulation), whereas parents’ displays of positive affect would be associated with RSA increases (i.e., good vagal regulation). We also separated the within-parent–teen dyad effect (i.e., changes within each parent’s affect across the 6 min) from the between-parent–teen dyad effect (i.e., overall levels of affect compared with other parents). Therefore, we hypothesized that parent anger and distress (within and between dyad) would be negatively associated with adolescent RSA, whereas parent positive affect (within and between dyad) would be positively linked to adolescent RSA in real-time interaction, controlling for RSA levels in the previous minute.

There is evidence that girls typically show better emotion-regulation skills than boys (e.g., Perry-Parrish & Zeman, 2011) and that emotion-regulation skills increase as children grow older (e.g., Eisenberg & Morris, 2003). There is also evidence that RSA continues to develop into adolescence (e.g., El-Sheikh, 2005a, 2005b; Rigterink et al., 2010) and that contextual factors affect the development of RSA (e.g., Katz & Rigterink, 2012). In addition, the associations between adolescent RSA and various outcomes differ between boys and girls (Diamond, Fagundes, & Cribbet, 2012). However, to our knowledge, there have been no published studies that have investigated sex and age differences in the relations between parent affect and adolescent RSA during social interaction. Thus, we explored the possible moderating roles of adolescent sex and age, but because of the lack of direct evidence, we did not have specific hypotheses.

**Method**

**Participants**

The sample consisted of 206 families with adolescents who participated in the Family and Youth Development Project (Cui et al., 2014, 2015), which focused on predictors and outcomes of emotion regulation. Data were collected from both adolescents ($M_{age} = 13.37$ years, $SD = 2.32$, age range = 10–18 years; 51% female; 29.6% European American, 32% African American, 19.4% Latino American, 19% other ethnic groups) and their primary caregivers (83.3% biological mothers, 10.7% biological fathers, 2% grandparents, 4% other caregivers). The sample predominantly comprised low-income families (median annual income = $40,000; 47.5% of families were receiving welfare or public assistance), with an average of 4.35 people living in each home and 38.7% headed by single parents. In our sample, 42.2% of adolescents reported having heard guns being shot, 46.1% had
seen someone being beaten up, 35.9% had seen other kids with
guns or knives at school or in their neighborhoods, 79.6% had
heard other kids threatening to beat someone up or hurt someone,
and 51.9% had been hit or pushed by someone.

Procedure
Participants were recruited from disadvantaged communities
through flyers using convenience and snowball sampling methods
(e.g., participants were given recruitment flyers to distribute to
friends). Following institutional review board–approved proce-
dures, the purpose and procedure of the study were explained to
adolescents and their primary caregivers before they signed assent
and consent forms, respectively, at a university research labora-
tory. Next, they were taken to separate rooms where research
assistants read all questions aloud while participants filled in
the questionnaires. After completing questionnaires and in the parent’s
presence, Biopac MP150 (Biopac Systems, Santa Barbara, CA)
cardiovascular (ECG100C) electrodes were attached to the adoles-
cent’s shoulder and sides and a respiratory (RSP100C) belt was
wrapped around the adolescent’s chest. Next, parents and adoles-
cents participated in several interaction tasks while being video-
taped. The current study used the electrocardiogram (ECG) and
respiration data collected during a 6-min parent–adolescent con-
flict discussion task. At the end of the 2-hr assessment, parent and
adolescent each received $60 compensation and were debriefed.

Measures and Task

Parent–adolescent conflict issues checklist. Prior to the con-
duction of the conflict discussion task, the parent and the adolescent rated the fre-
quency of their daily disagreements using the modified Conflict
Frequency Scale (Melby et al., 1998). The 30-item instrument
covered different aspects of adolescent daily life: cleaning up/chores,
free time, family rules, appearance/health, respect/man-
ers, noise, how the family gets along, supervision, money, smok-
ing/alcohol, friends/dating, school, and other issues. For each item,
the parent and the adolescent independently rated how often in the
past year they had had disagreements about these issues on a
5-point scale ranging from 1 (never) to 5 (very often). Cronbach’s
alpha was .93 for adolescent report and .92 for parent report.

Parent–adolescent conflict discussion task. On the basis of
the ratings using the Conflict Frequency Scale, research assistants
chose five disagreements rated high in frequency by both parent
and adolescent for the dyad to discuss. Specifically, the parent and
adolescent were asked to discuss disagreements that they had in
daily life and come up with as many solutions to the issues as they
could in 6 min. For each issue, the following questions were used
to guide them through the discussion: (a) “What is the conflict we
seem to have about this issue?” (b) “When do we have this conflict
and who is involved?” (c) “What usually happens?” (d) “What can
we do to solve this problem? (Please try to agree on a single
solution).”

Observed parent affect. Using a coding system adapted from
Morris et al. (2011), parents’ anger, internalized distress (primarily
sadness and anxiety), and positive affect were coded offline on the
basis of parents’ facial expressions, voice tone, and body language
during the conflict discussion task. Affect was coded every 15-s
epoch on a 5-point scale ranging from 1 (no sign of the emotion)
to 5 (exceptionally strong display of emotion). An affect coding
manual provided detailed descriptions of facial expression, voice
tone, and body language for each scale point and for each type of
affect. For example, smile; lips parted with the teeth and jaw
together in a grin; soft and warm soothing, slightly faster or louder
than usual voice; moderate physical affection (touch, pat on back);
and open body position would be coded as a 3 for positive affect.
Cheeks raised and brows obviously slanting toward the center,
hostile or sarcastic tone of voice, and slight to moderate body
tensing (slightly balled fists, little raise of the shoulders) would be
coded as a 3 for anger. For parent internalized distress, raised inner
corners of eyebrows; protruded bottom lip (as if pouting); quaver-
ing voice; low, monotone, or depressed tone of voice; and notice-
able drop of head or slump in shoulders would be coded as a 3 for
sadness. Drawn back lips; raised upper eyelid; elevated or frantic
voice tone; rapid, repetitive body movements; and trembling
hands, lips, or mouth would be coded as a 3 for anxiety. Different
coders coded each parent affect factor. Twenty-two percent of the
videos were double-coded, and the intercoder reliabilities were
high: intraclass correlations (ps) were .81 for anger, .86 for internal
distress, and .82 for positive affect. To allow matching with RSA
and respiration data, parent affect for every group of four 15-s
epochs were averaged to achieve a composite affect score for
every minute of the task.

RSA and respiration rate. Adolescent ECG and respiration
pneumograph were recorded using the Biopac MP150 system. The
sampling frequency was 2 kHz for both ECG and respiration
signals. ECG and respiration data were imported to MindWare
HRV 3.0.9 software (Gahanna, OH [http://www.mindwaretech.
com]) to calculate RSA values and respiration rate minute by
minute during the conflict discussion task. The MindWare HRV
3.0.9 program’s power spectral analysis was used. ECG artifacts
were automatically detected by the MindWare program and also
manually edited to obtain reliable measures of RSA. RSA values
that were out of the high respiratory frequency band (0.12–0.40
Hz) were discarded and not used in further analyses. Full-
information maximum likelihood estimation was used in HLM 7.0
program to handle missing values (Scientific Software Interna-
tional, Skokie, IL).

Analytic Strategy
To test the relations between parent affect and adolescent RSA
in real time both concurrently (no-lag) and 1 min later (lag-1), we
computed two-level hierarchical linear models. Specifically, we
examined the relations between parent affect (anger, distress, or
positive affect) and adolescent’s RSA levels either concurrently or
1 min later, controlling for the concurrent adolescent respiration
parameters (respiration rate) and adolescents’ previous-minute
RSA. All analyses were conducted in HLM 7.0, and each parent
affect factor was tested in separate models. Group-mean centering
was used to separate within-parent—teen dyad and between-parent–
teen dyad effects for parent affect. It also enabled the model to test
possible interaction effects of the within-dyad effect of parent
affect (PA, in no-lag models, PA_1 in lag-1 models) with dyad-
level variables (i.e., PA_overall, sex, and age) predicting b, in the
following models. The following no-lag (concurrent) models were
tested:
PARENT AFFECT AND ADOLESCENT RSA

Level 1: $RSA_t = b_0 + b_1PA_t + b_2RSA_{t-1} + b_3RR_t + \epsilon_t$;

and

Level 2: $b_0 = \gamma_{00} + \gamma_{01}PA_{\text{overall}} + \gamma_{02}\text{Sex} + \gamma_{03}\text{Age} + \nu_0$,

$b_1 = \gamma_{10} + \gamma_{11}PA_{\text{overall}} + \gamma_{12}\text{Sex} + \gamma_{13}\text{Age} + (\nu_1)$,

$b_2 = \gamma_{20} + \gamma_{21}\text{Sex} + \gamma_{22}\text{Age} + (\nu_2)$,

$b_3 = \gamma_{30} + \gamma_{31}\text{Sex} + \gamma_{32}\text{Age} + (\nu_3)$.

For the lag-1 model, $PA_t$ was replaced by $PA_{t-1}$ at Level 1, and Level 2 models were kept the same. At Level 1, $RSA_{t-1}$ and $RR_t$ were centered on their group means, and $PA_t$ or $PA_{t-1}$ were centered on the group mean such that $b_0$ represented each adolescent’s average RSA; $b_1$ represented the within-dyad influence of parent affect from either the concurrent $(t)$ or prior lag $(t-1)$ on the adolescent’s RSA at time $t$, which was of primary interest; $b_2$ represented the lag-1 influence of RSA (autoregressive effect); and $b_3$ represented the influence of concurrent respiration rate at time $t$.

At Level 2, each dyad’s Level-1 $b_0$ and $b_1$ coefficients were predicted by $PA_{\text{overall}}$ (group mean of each parent’s affect at Level 1), and all $b$ coefficients were predicted by each adolescent’s sex and age. All Level-2 predictors were centered on their grand mean so that the overall intercept $\gamma_{00}$ would be the overall mean RSA outcome score. The predictors of the Level-1 intercept $b_0$ indicated main effects of the Level-2 predictors, whereas the predictors of the other Level 1 coefficients were tests of cross-level interactions to examine whether each of the other Level-1 coefficients (slopes) varied by their Level-2 predictors (mean parent affect $PA_{\text{overall}}$, adolescent sex, and adolescent age). For example, $\gamma_{01}$ represented the between-dyad main effect of parent affect, $\gamma_{10}$ represented the average within-dyad effect of parent affect, and $\gamma_{11}$ represented the interaction effect of between- and within-dyad parent affect. Similarly, the gamma coefficients for adolescent sex and age represented their moderating effects on the three Level-1 slope coefficients.

Residual terms (in parentheses in the equations) were trimmed in final models because they were not significant.

Results

Descriptive Analyses

Descriptive statistics for the parent–adolescent conflict frequency, adolescent RSA and respiration rate, and parent affect factors are shown in Tables 1 and 2. The means of parent and adolescent reports of conflict frequencies were generally not significantly correlated, suggesting that they generally did not have many disagreements about various issues. The conflict discussion task may have been mildly stressful as parents also generally displayed low levels of anger and distress (see Table 1).

Bivariate Correlations Among Major Variables

Bivariate correlations indicated that parents displayed similar levels of anger, distress, and positive affect toward girls and boys during the task. Parents showed significantly more positive affect toward older adolescents than younger ones ($r$ ranging from .19 to .25, $p < .01$). No age or sex differences were found in adolescent RSA or respiration rates (see Table 2). Both adolescent- and parent-reported conflict frequencies were generally not correlated with RSA or respiration rates (see Table 2). Each parent affect, RSA, and respiration rate factor was fairly stable across the task (see Tables 2 and 3). Parent anger, distress, and positive affect were generally not correlated (see Table 3), suggesting that the three types of parent affect were mutually exclusive. Parent anger and distress were not associated with adolescent RSA concurrently or across time. Parent positive affect was positively related to RSA concurrently during the 1st and 5th min and also across time for various minutes (1st-min affect with 1st-, 2nd-, 5th-, and 6th-min

Table 1

Means (M), Standard Deviations (SD), Minima, and Maxima of Parent Affect

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<tr>
<th>Variable</th>
<th>Overall anger</th>
<th>A M1</th>
<th>A M2</th>
<th>A M3</th>
<th>A M4</th>
<th>A M5</th>
<th>A M6</th>
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<th>Overall distress</th>
<th>D M1</th>
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<th>Overall positive</th>
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<th>P M2</th>
<th>P M3</th>
<th>P M4</th>
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Note. A = anger; M1–M6 = 1st–6th min of the task; D = distress; P = positive.
### Table 2

**Correlations Among Sex, Age, Conflict Frequency, RSA, and Respiration Rate**

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**Note.** RSA = respiratory sinus arrhythmia; Con = conflict frequency; A = adolescent report; P = parent report; M1–M6 = 1st–6th min of the task; RR = respiration rate.

* p < .05. ** p < .01. *** p < .001.

### Table 3

**Correlations Among Parent Anger, Distress, and Positive Affect**

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**Note.** A = anger; M1–M6 = 1st–6th min of the task; D = distress; P = positive.

* p < .05. ** p < .01. *** p < .001.
RSA; 3rd-min affect with 5th-min RSA \( [r_s \text{ ranging from } .16 \text{ to } .27, p < .05] \). Parent- and adolescent-reported conflict frequency were generally not significantly correlated with parent anger or distress, and parent-reported conflict frequency was negatively correlated with parent positive affect in all 6 min \( [r_s \text{ ranging from } -1.6 \text{ to } -2.7, p < .05] \), suggesting that parents were less likely to display positive affect if they reported high levels of disagreements with their adolescents.

**Associations Between Parent Affect and Adolescent RSA**

Results of multilevel modeling (MLM) showed that within-dyad affect was not significantly linked to adolescent RSA during the current interval \( (\text{i.e., in no-lag models}) \). However, between-dyad positive affect was significantly related to adolescent RSA, which also remained significant in the lag-1 model (see Table 4). Therefore, only the lag-1 model results are discussed in the following.

**Anger lag-1 model.** As expected, parent anger was negatively associated with subsequent adolescent RSA as a within-dyad effect \( (\text{i.e., higher anger related to RSA decreases}; \gamma_{10} = -0.09, p = .001) \). This negative effect was significantly stronger for older adolescents than for younger ones \( (\gamma_{13} = -0.08, p = .007; \text{see Table 4}) \). To probe this moderating effect, a series of hypotheses were tested in HLM 7.0 to find the age point at which the associations first became significant. Results indicated that the association of parent anger with reduced subsequent RSA became significant for adolescents who were at least 13 years old \( (b_1 = -0.06, p = .03) \). Consistent with the correlational and no-lag results, however, there was no between-dyad association between parent anger and adolescent RSA \( (\gamma_{01} = 0.01, p = .88) \).

**Distress lag-1 model.** Contrary to expectations, parent distress was not significantly associated with adolescent RSA either as a within-dyad effect \( (\gamma_{10} = 0.01, p = .85) \) or as a between-dyad association \( (\gamma_{01} = 0.01, p = .90; \text{see Table 4}) \).

**Positive affect lag-1 model.** As expected, parent positive affect was positively associated with subsequent adolescent RSA as a within-dyad effect \( (\gamma_{10} = 0.08, p = .01) \). This effect was significantly moderated by adolescent sex, however \( (\gamma_{12} = -0.06, p = .045; \text{see Table 4}) \). Further testing demonstrated that the within-dyad association between parent positive affect and adolescent RSA was significant and positive for girls \( (b_1 = 0.14, p = .001) \) but not for boys \( (b_1 = 0.01, p > .50) \). Moreover, parent positive affect was also positively related to adolescent RSA as a between-dyad association \( (\gamma_{01} = 0.19, p = .004) \), and this association did not differ for girls and boys or among younger versus older youths.

**Discussion**

The current study examined adolescent cardiac vagal regulation during a social interaction in real time and analyzed the relation between dynamic changes in parent affect and changes in adolescent RSA levels via MLM. Overall, we found that within-dyad anger was associated with RSA decreases 1 min later and that both within-dyad positive affect and between-dyad positive affect were associated with RSA increases 1 min later. These findings suggest that parent affect displayed during parent–adolescent interactions influences adolescents’ cardiac vagal regulation.

Parent Affect and Adolescent RSA

Our findings are consistent with the notion that parenting influences ANS functioning, adding empirical evidence that parent affect may contribute to adolescents’ real-time physiological regulation. Our findings also suggest that contextual effects on ANS functioning continue from childhood to adolescence. Most of the research in this area has been conducted among infants or young children, focusing on the long-term effects of early contextual factors on adjustment \( (\text{e.g., Katz & Rigterink, 2012; Loman, Gunnar, & the Early Experience, Stress, and Neurobehavioral Development Center, 2010; Rigterink et al., 2010}) \). Although we have known that positive family climate, maternal sensitivity, parent emotion regulation, and parents’ positive reactions to children’s negative emotions all contribute to children and adolescents’ self-regulatory skills \( (\text{e.g., Fosco, Caruthers, & Dishion, 2012; Kim et al., 2009; Valiente, Lemery-Chalfant, & Reiser, 2007}) \), less is known about why and how these family contexts and parenting factors contribute to adolescent emotion regulation. Even less is known about how parenting is linked to adolescent physiological regulation. The findings of the current study suggest that one underlying mechanism may be parent affect displayed toward the child while parenting. In highly cohesive families, parents tend to be sensitive, have adaptive emotion-regulation skills, and are positive and supportive \( (\text{e.g., showing more positive affect}) \) when their children display negative emotions \( (\text{e.g., Eisenberg et al., 2001}) \). Our study advances the literature by demonstrating that parent positive affect relates to better vagal regulation, which may reflect better emotion regulation among children and adolescents, which, in turn, is likely linked to positive outcomes. In contrast, parents from low-cohesion and high-conflict families are often insensitive, have poor self-regulation, and tend to show negative emotions \( (\text{e.g., anger}) \) toward their children, which—according to our findings—may dampen child vagal regulation and lead to poor emotion regulation and problem behaviors.

Our findings are also in line with recent brain-imaging research, which has found that, compared with children and adults, adolescents show exaggerated amygdala activity while seeing both fearful and happy faces \( (\text{Hare et al., 2008}) \), suggesting that adolescents are sensitive and physiologically responsive to environmental emotional cues such as parents’ emotion expression. It is possible that exposure to constant negative and/or unpredictable parent affect may expose adolescents to a chronic stressful context that could dampen their emotion-regulation abilities \( (\text{e.g., Jackson et al., 2011; Jaser et al., 2008; Valiente et al., 2007}) \). Conversely, if parents are able to show more positive affect while interacting with their children, even discussing disagreements or conflict issues, the children may benefit from a responsive and warm environment and develop better vagal regulation. However, more research is needed to explore how parenting—particularly parent affect—shapes the

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\[1\] We explored whether the associations between parent affect and adolescent RSA reactivity differed in terms of parent–adolescent relationship \( (\text{e.g., parental acceptance, parent–adolescent openness}) \). Three-way interactions of parent affect, parent–adolescent relationship, and adolescent sex or age were also tested. In addition, we tested whether parent negative affect interacted with positive affect in predicting adolescent RSA reactivity. No significant interaction effects were found.
perhaps having an overall higher sensitivity to positive parenting, value interpersonal connectedness and are sensitive to and connect with other parents, which suggests that, compared with boys, girls are more positive affect relative to their own overall positive affect (Eisenberg et al., 2001, 2008). Moreover, when parents showed maintaining high levels of RSA, for both girls and boys (e.g., during social interaction provided a safe environment for adolescents’ psychophysiological regulation (e.g., Morris et al., 2007). It is possible that parents’ positive affect displayed during social interaction provided a safe environment for adolescents to engage in the social activity, which was supported by maintaining high levels of RSA, for both girls and boys (e.g., Eisenberg et al., 2001, 2008). Moreover, when parents showed more positive affect relative to their own overall positive affect across the discussion, girls showed RSA increases. This effect was above and beyond overall higher parent positive affect compared with other parents, which suggests that, compared with boys, girls may be more sensitive to parents’ positive emotional cues as they value interpersonal connectedness and are sensitive to and concerned for others and more empathetic to others (Gilligan, 1982), perhaps having an overall higher sensitivity to positive parenting, particularly within mother–daughter relationships. The association

Table 4
Multilevel Models of Parent Affect and Adolescent RSA (Lag-1)

<table>
<thead>
<tr>
<th>Fixed effect</th>
<th>Anger model</th>
<th>Distress model</th>
<th>Positive affect model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>SE</td>
<td>t</td>
</tr>
<tr>
<td>$b_0$ (intercept)</td>
<td>-0.02</td>
<td>0.07</td>
<td>-0.31</td>
</tr>
<tr>
<td>$\gamma_{00}$</td>
<td>0.01</td>
<td>0.07</td>
<td>0.16</td>
</tr>
<tr>
<td>$\gamma_{01}$ (between dyad)</td>
<td>-0.02</td>
<td>0.07</td>
<td>-0.28</td>
</tr>
<tr>
<td>$\gamma_{02}$ (sex)</td>
<td>-0.09</td>
<td>0.07</td>
<td>-1.22</td>
</tr>
<tr>
<td>$\gamma_{03}$ (age)</td>
<td>-0.09**</td>
<td>0.03</td>
<td>-3.33</td>
</tr>
<tr>
<td>$b_1$ (PAa$_{0-1}$)</td>
<td>-0.15***</td>
<td>0.04</td>
<td>-3.90</td>
</tr>
<tr>
<td>$\gamma_{10}$ (within dyad)</td>
<td>-0.01</td>
<td>0.02</td>
<td>-0.58</td>
</tr>
<tr>
<td>$\gamma_{11}$ (interaction)</td>
<td>0.04</td>
<td>0.04</td>
<td>1.04</td>
</tr>
<tr>
<td>$\gamma_{12}$ (sex)</td>
<td>-0.03</td>
<td>0.02</td>
<td>-1.51</td>
</tr>
<tr>
<td>$\gamma_{13}$ (age)</td>
<td>-0.13***</td>
<td>0.04</td>
<td>-3.74</td>
</tr>
<tr>
<td>$b_2$ (RSA$<em>{a</em>{i-1}}$)</td>
<td>-0.01</td>
<td>0.02</td>
<td>-0.58</td>
</tr>
<tr>
<td>$\gamma_{20}$</td>
<td>0.04</td>
<td>0.04</td>
<td>2.13</td>
</tr>
<tr>
<td>$\gamma_{21}$ (sex)</td>
<td>-0.03</td>
<td>0.02</td>
<td>-1.51</td>
</tr>
<tr>
<td>$\gamma_{22}$ (age)</td>
<td>-0.15***</td>
<td>0.04</td>
<td>-3.90</td>
</tr>
<tr>
<td>$b_3$ (RR)</td>
<td>-0.03</td>
<td>0.02</td>
<td>-1.51</td>
</tr>
</tbody>
</table>

Note. All variables were standardized so that coefficient estimates reflect effect sizes. RSA = respiratory sinus arrhythmia; PA = parent affect (i.e., anger, distress, positive affect); interaction = interaction of between- and within-dyad effects; RR = respiration rate.

*p < .05. **p < .01. ***p < .001.
between parent positive affect and adolescent RSA suggests that even among adolescents living in disadvantaged neighborhoods, positive parenting (e.g., more positive affect) influences adolescents in an adaptive way.

**Parent distress.** Unexpectedly, neither within- nor between-dyad distress was significantly associated with adolescent RSA during the same interaction. It is possible that parent distress or sadness, which is less overt, is more difficult to detect by adolescents compared with anger and positive affect, resulting in a weaker influence on adolescents. It is also possible that parent distress (e.g., sadness) might make empathetic adolescents feel similar emotions but not show specific physiological response patterns (see Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). Low levels of parent distress may also indicate that the conflict discussion task did not induce adequate distress from parents or that parent distress as an internal state was more difficult to observe accurately by independent coders compared with anger and positive affect.

 Unexpectedly, we also did not find significant associations between within-parent affect and adolescent RSA concurrently. The effects lagged 1 min. One reason for this might be that parent affect was aggregated across the 1-min interval, and it took time, or a buildup, for the effects of parents’ affect to affect RSA. More studies are needed to confirm this notion. However, we found a significant lag-1 association between parent anger and low levels of RSA, which may suggest a sustaining, heightened physiological arousal (inability to regulate) in response to parent anger. The concurrent and prolonged lag-1 effects of parent positive affect on adolescent RSA increases may also indicate that RSA reactivity to parent affect in the current study reflected vagal regulation. Although a 1-min period is necessary to obtain reliable RSA scores in MindWare using the power spectral method, effects on other psychophysiological indicators requiring shorter intervals, such as the pre-ejection period or skin-conductance level, should be tested in the future.

**Strengths and Limitations**

One of the strengths of the current study is that we used a process perspective to model the dynamic changes in parent affect and adolescent RSA across the interaction task, which allowed us to capture the relations between dynamics of parent affect and adolescent cardiac vagal regulation. A second strength was that we differentiated between- and within-individual variations of parent affect in relation to adolescent RSA levels in MLM and found differential associations of the within- and between-individual variations in parent affect. A third strength was that RSA was captured in an ecologically valid interpersonal social communication setting (i.e., parent–adolescent discussion of self-chosen disagreements). The environment for measuring RSA is arguably very important in understanding the role of RSA (Obradovic, Bush, & Boyce, 2011) and should be considered in future studies.

Despite these strengths, there were some limitations to the current study. First, we were not able to determine causality despite strong theoretical evidence in the literature. As such, the direction of the effects cannot be determined. It is possible that among well-regulated adolescents (with high RSA during social interactions), compared with less regulated youths, it is easier for parents to maintain positive emotions during a difficult discussion. Second, it should be noted that the magnitudes of the associations were somewhat small in our study, especially the within-parent fluctuations in anger and positive affect. Dynamic changes in parent affect were subtle, which reflects the fact that our conflict discussion task was a mildly stressful social interaction task. However, it is possible that stronger links could be found with a somewhat more stressful interaction task and/or in the presence of stronger parent negative affect. Third, we did not test the relations between adolescent cardiac vagal regulation and adolescent behavioral emotion regulation and adjustment outcomes. Such links should be investigated in future studies.

**Conclusions and Implications**

The current study used MLM to investigate the relations between dynamic changes in parent affect and adolescent’s real-time cardiac vagal regulation during a social interaction task. This contributes to the current literature on parenting influences on child biology and vagal regulation by providing evidence that a parent’s affect predicts adolescent RSA in real time. The new generation of research on physiology and emotion would benefit from adopting a dynamic and process view of regulation and by studying real-time emotion dynamics. Future research would also be enhanced by distinguishing between- from within-individual effects. The current study also points out the significance of parent emotions displayed while parenting children and adolescents.

**References**


PARENT AFFECT AND ADOLESCENT RSA


Revision received January 14, 2015
Accepted January 16, 2015