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Emotion dysregulation and dyadic conflict in depressed and typical adolescents: Evaluating concordance across psychophysiological and observational measures

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ABSTRACT

Many depressed adolescents experience difficulty in regulating their emotions. These emotion regulation difficulties appear to emerge in part from socialization processes within families and then generalize to other contexts. However, emotion dysregulation is typically assessed within the individual, rather than in the social relationships that shape and maintain dysregulation. In this study, we evaluated concordance of physiological and observational measures of emotion dysregulation during interpersonal conflict, using a multilevel actor-partner interdependence model (APIM). Participants were 75 mother-daughter dyads, including 50 depressed adolescents with or without a history of self-injury, and 25 typically developing controls. Behavior dysregulation was operationalized as observed aversiveness during a conflict discussion, and physiological dysregulation was indexed by respiratory sinus arrhythmia (RSA). Results revealed different patterns of concordance for control versus depressed participants. Controls evidenced a concordant *partner* (between-person) effect, and showed increased physiological regulation during minutes when their partner was more aversive. In contrast, clinical dyad members displayed a concordant actor (within-person) effect, becoming simultaneously physiologically and behaviorally dysregulated. Results inform current understanding of emotion dysregulation across multiple levels of analysis.

1. Introduction

Adolescent depression is a pervasive and impairing condition characterized in part by emotion dysregulation and sensitivity to interpersonal conflict (Allen, Kuppens, & Sheeber, 2012). The prevalence rate of depression increases markedly during adolescence (Lewinsohn, Hops, Roberts, Seeley, & Andrews, 1993), making this an opportune stage to observe the dynamic interplay of emotion dysregulation and interpersonal stress. Considerable socialization of both conflict resolution strategies and emotion regulation/dysregulation occurs within family relationships (Eisenberg, 2000; Morris, Silk, Steinberg, Myers, & Robinson, 2007). Parents and children shape one another's behaviors, emotions, and physiological responses through dyadic interaction patterns that occur thousands of times across development (see e.g., Patterson, Dishion, & Bank, 1984). Thus, parent–child conflict represents an ideal context in which to observe emerging regulatory strategies.

Emotion regulation comprises biological and social processes. However, few studies have examined both simultaneously. This is unfortunate given evidence that emotion regulation develops through interpersonal mechanisms (Cassidy, 1994; Coan, 2010; Crowell, Baucom, et al., 2013; Crowell, Skidmore, Rau, & Williams, 2013). A variety of labels have been applied to social processes that promote emotion regulation, including attunement, co-regulation, external regulation, synchrony, and mutual regulation (Coan, 2010; Helm, Sbarra, & Ferrer, 2012; Hughes, Crowell, Uyeji, & Coan, 2012). Regardless of the label used, the regulatory power of social relationships is well documented; vocal cues, touch, instrumental support, and emotion coaching are potent sources of regulation for infants and children (see Campos, Campos, & Barrett, 1989, for a review). Such co-regulation may be especially important in childhood and early adolescence, before neural systems implicated in top-down volitional modulation of affect have matured fully (see e.g., Beauchaine & McNulty, 2013). Yet even in adulthood, co-regulation within relationships contributes to better

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self-control, health, and interpersonal connectedness (Coan, Kasle, Jackson, Schaefer, & Davidson, 2013; Diamond & Aspinwall, 2003; Pietromonaco, Uchino, & Dunkel Schetter, 2013). Thus, social relationships serve powerful self-regulatory functions (Hofer, 1995; Hughes et al., 2012).

In most studies, emotion is assessed intrapersonally (e.g., Reis, Collins, & Berscheid, 2000), and emotion regulation is described as a set of processes through which an *individual*—either volitionally or automatically—modulates the intensity, duration, or valance of an emotion to meet contextual demands (Cole, Martin, & Dennis, 2004; Gross, 1998). According to nearly every theory, emotions are described as coordinated behavioral, physiological, and cognitive response tendencies (e.g., Ekman & Friesen, 1976). For example, anxiety facilitates survival-related behavior and physiological activation in response to threat. When the threat is removed or appraised differently, behavioral and physiological recovery should occur (Cole et al., 2004; Gross, 1998). However, stimulus conditions are rarely so simple or circumscribed. Rather, biological, social, behavioral, and cognitive systems each act upon one another to produce dynamic emotional states, and regulation (or dysregulation) of these states. This has led many scholars to promote multi-method, multiple-levels-of-analysis approaches to the study of emotion and emotion regulation (Beauchaine & McNulty, 2013; Beauchaine & Gatzke-Kopp, 2012; Calkins, 2010). As a result, we now have a richer understanding of the complexity that follows from gathering data across multiple levels of analysis.

2. Concordance: a multimethod approach

Concordance can be defined as a coordinated response across subjective, cognitive, expressive, and physiological measures of emotion (see e.g., Hollenstein & Lanteigne, in this issue; Marsh, Beauchaine, & Williams, 2008). According to functionalist accounts, concordance reflects emotional wellbeing, whereas discordance may indicate vulnerability to psychopathology (Ekman, 1999; Levenson, 1994). However, after several decades of empirical study, evidence in support of this theory is inconsistent (Marsh et al., 2008; Lanteigne, Flynn, Eastabrook, & Hollenstein, 2012). This has led some to conclude that emotional response systems are only loosely or probabilistically correlated, and that concordance may only be observed during the experience of very strong emotions, or in specific contexts (Cacioppo, Berntson, & Klein, 1992; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005; Reisenzein, 2000). Notably, these arguments apply to intrapersonal concordance. Assessing interpersonal concordance is even more complicated, since each participant's behavioral and physiological responses are affected by both endogenous experiences and partner behaviors.

In addition, much of the existing literature has tested concordance hypotheses during tasks designed to elicit specific, discrete emotions (e.g., anger or sadness; Hubbard et al., 2004; Reisenzein, Studtmann, & Horstmann, 2013). In these study designs, emotion regulatory efforts could disrupt attempts to measure concordance, producing inconsistent results (Butler et al., in this issue; Mauss et al., 2005). Thus, there are two distinct and conflicting hypotheses that follow from research with typical controls. On the one hand, healthy participants should show greater concordance across measures of emotion relative to clinical participants because concordance presumably reflects wellbeing (Marsh et al., 2008). On the other hand, controls may evidence less concordance if they have better emotion regulation skills and are actively regulating or suppressing their expressions (Mauss et al., 2005).

3. The present study

In the present study, we examined minute-to-minute concordance across physiological and behavioral markers of emotion dysregulation during a mother–daughter conflict task. We also explored how patterns of concordance/discordance differ between typical mother-daughter dyads (controls) and those in which the daughter is depressed (clinical). We operationalized behavior dysregulation as observed aversiveness during conflict, and physiological dysregulation as respiratory sinus arrhythmia (RSA) reactivity. Unique to this study, we model concordance simultaneously within each dyad member (e.g., concordance between the mother's RSA and her own aversive behavior) and between members (e.g., concordance between the mother's RSA and her adolescent's aversive behavior). This is a more thorough test of concordance within an interpersonal stress paradigm than most studies conducted to date.

3.1. Respiratory sinus arrhythmia

Respiratory sinus arrhythmia is often used as a psychophysiological index of emotion regulation capacity (see Beauchaine, 2001, 2012; Porges, Doussard-Roosevelt, Portales, & Greenspan, 1996). Interest in RSA follows from polyvagal theory (PVT; Porges, 1995), including its application to both normative development of emotion regulation (e.g., Hinnant, Elmore-Staton, & El-Sheikh, 2011) and the development of emotion dysregulation in psychopathology (e.g., Beauchaine, 2001; Beauchaine, Gatzke-Kopp, & Mead, 2007). According to PVT, parasympathetic efference to the heart (from the nucleus ambiguous through the vagus nerve) serves to inhibit fight/flight (F/F) responding and promote adaptive behaviors, including social affiliation (Beauchaine et al., 2007; Porges, 2007).

When faced with conspecifics, mammals must decide quickly whether to affiliate, initiate F/F behaviors, or withdraw/freeze (Porges, 2003). Affiliation requires sustained attention, which is served through increased vagal activity. In contrast, conflict requires rapid mobilization of sympathetically mediated cardiac output, which is often accompanied by vagal withdrawal (see Beauchaine, 2001; Beauchaine et al., 2007; Porges, 1995). Following from these functional relations, estimates of vagal activity and reactivity may serve as a peripheral measures of self-regulation in contexts of interpersonal interactions. Increases in vagal activity may mark better regulation in the service of social affiliation, whereas decreases in vagal activity often reflect compromised regulatory capacity.[1]

3.2. Behavioral dysregulation

Behaviorally, emotion regulation is often measured through self-reports or observational coding. Analytic approaches vary, but many scholars suggest that emotion and its regulation should be assessed independently (Cole et al., 2004). However, this presents a measurement challenge because participants often anticipate their emotional reactions and modify their responses accordingly (e.g., through cognitive reinterpretation or avoiding the situation). In contrast, emotion *dysregulation* is easier to identify and measure behaviorally. According to one useful definition, dysregulated emotions are characterized by four central features: (1) they persist for too long and attempts at regulation are ineffective; (2) they interfere with appropriate behavior; (3) they are inappropriate to the context; and/or (4) they change too abruptly

[1] Under appropriate stimulus conditions (e.g., control of posture, respiration, movement), vagal efference to the heart can be estimated by RSA and psychological interpretation is possible (see Ritz, 2009; Zisner & Beauchaine, 2014). When ideal conditions are not met, RSA may nevertheless be a useful marker of clinical state. For example, deficiencies in RSA appear to index emotion dysregulation across a wide range of psychiatric disorders (see Zisner & Beauchaine, 2014).

or too slowly (Cole, Hall, & Hajal, 2013). Thus, whereas emotion regulation often occurs internally, emotion dysregulation can be observed and coded objectively. In a laboratory conflict discussion, for example, dysregulation might be defined by escalating negative emotional exchanges that are less responsive to self- or co-regulation attempts.

4. Hypotheses

Following from this review, we seek to characterize minute-to-minute concordance across physiological (RSA reactivity) and behavioral (observed aversiveness) dysregulation during conflict. We define concordance as the minute-to-minute covariation of physiology and observed behavior. In contrast, discordance is defined as the lack of an association across levels of analysis. As noted above, we are interested in both intra- and interpersonal concordance. Indeed, physiological dysregulation during conflict could be tied to one's own behavior (i.e., an actor effect) or the behavior of one's partner (i.e., a partner effect). Furthermore, patterns of concordance may differ based upon group status.

4.1. Intrapersonal concordance

Clinical depression is often characterized by ruminative self-focus that is non-responsive to external modulation (e.g., Pyszczynski and Greenberg, 1987). This suggests that depressed participants should show concordance between their own behavioral and physiological dysregulation. In addition, several studies indicate that depressed children, adolescents, and adults exhibit RSA withdrawal in response to stress, consistent with theories that vagal withdrawal is associated with poor emotion regulation (e.g., Boyce et al., 2001; Carney et al., 2000; Crowell et al., 2005). Thus, for depressed participants we predicted a negative association between their own aversive behavior and RSA reactivity (i.e., increased aversiveness corresponding with RSA withdrawal; concordance). We also predicted a concordant within-person response for mothers of depressed participants, given familiality of both depression and emotion dysregulation (Cummings & Davies, 1994). For control participants and their mothers, we hypothesized that there would be no association between the participant's aversive behavior and their own RSA reactivity (i.e., discordance).

4.2. Interpersonal concordance

Recently, many scholars have become interested in understanding dyadic emotional exchanges rather than individual emotional response systems (see e.g., Butler & Randall, 2013). Whether the context is parent–child, spousal, sibling, or therapist-client, emotions often occur within relationships. Until recently, methods for assessing dyadic emotion have lagged behind theories of their effects on relationships. However, this has begun to change due to advanced statistical techniques and reduced costs of psychophysiological data collection. For example, the temporal interpersonal emotion system (TIES) model (Butler, 2011) describes current approaches to assessing behavioral, physiological, and subjective aspects of emotion within dyads. Butler describes relationships as dynamic, self-organizing systems in which present states are affected by relationship structure, past states (e.g., current levels of conflict are similar to past levels of conflict), and moment-to-moment feedback processes. In other words, emotional responses of one person depend upon emotional states of the other, and these associations are dependent upon the nature of the relationship: a three-way interaction.

In control mother-daughter dyads, physiological responses are likely to track with partner—rather than one's own—behavior. This would follow from theories that healthy relationships are characterized by high responsiveness to one another's emotional cues (e.g., Coan et al., 2013). Furthermore, according to polyvagal theory, social orienting and attentiveness to partner behavior would be marked by increases in RSA. Thus, we hypothesized that members of control dyads would show a positive association between their *partner's* behavior and their own RSA (i.e., between-person concordance). Similarly, we theorized that the clinical dyads would show no association between partner behavior and RSA (i.e., discordance), consistent with theories of depressive self-focus (Pyszczynski and Greenberg, 1987).

5. Method

5.1. Participants

Participants included 75 female adolescents, ages 13–17 years, who were enrolled in one of three groups: depressed + self-injuring (SII), depressed with no self-injury history (DPR), and control (CTR). Both SII and DPR adolescents met *Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision* (American Psychiatric Association, 2000) criteria for major depression, and were aggregated as a single clinical group for or all analyses. Initially, 84 mother-teen dyads were enrolled and completed some study procedures. However, nine participants had insufficient data to be analyzed due to inability/refusal to return for the physiological assessment ($n = 4$), failure of physiological equipment ($n = 3$), or arriving with a guardian other than the biological mother ($n = 2$), which resulted in the final sample of 75. These nine did not differ from the overall sample on any demographic or diagnostic variables, all $Fs < 1.07$, all $ps > 0.29$, all $\eta^2 < 0.02$.

Inclusion and exclusion criteria, participant demographics, and screening procedures are detailed elsewhere (see Crowell et al., 2012). Briefly, the mean age of participants was 16.1 years ($SD = 1.3$). The sample was 70.2% Caucasian, 7.1% African American, 6.0% Asian American, 4.8% Latina, 1.2% Native American, and 10.7% of mixed racial/ethnic heritage. Due to potential effects on psychophysiological recordings, adolescents and parents were excluded if they were taking beta blockers, mood stabilizers, benzodiazepines, or had taken recreational drugs (confirmed via urinalysis). Adolescents who were taking prescription stimulants ($n = 3$) were included if the parent and adolescent agreed to a 36-h washout prior to assessment. No parents were taking stimulants. Participants completed two assessments and were given $20 for completing Visit 1 and an additional $40 after completing Visit 2. Study procedures were approved by the institutional review board at Seattle Children's Hospital. Written informed assent and consent were obtained from adolescents and mothers, respectively.

5.2. Procedure

At Visit 1, adolescents and their mothers completed diagnostic interviews and self-report measures to confirm presence of depression (clinical group) or no psychopathology (controls). These measures are reported elsewhere and are not the focus of the current study (see Crowell et al., 2012). Adolescents and mothers were then scheduled to return approximately 2 weeks later to participate in a psychophysiological assessment, including a conflict discussion. This assessment was conducted in a sound-attenuated room that was monitored with audio–video recording equipment. Prior to the discussion, both dyad members completed the Issues Checklist (Prinz, Foster, Kent, & O'Leary, 1979), a 44-item questionnaire used to identify a discussion topic (e.g., chores, privacy). Responses on the checklist were rated on frequency, ranked from 1 (*never*) to 5 (*very often*), and intensity, ranked from 0 (*calm*) to 40 (*intense*). A trained research assistant then chose a topic based on the best match between the adolescent and mother on severity and frequency. For all dyads, the selected topic did not exceed an intensity level of 20, which resulted in intense discussions but also minimized the possibility of extreme distress.

5.3. Psychophysiological assessment

Electrocardiograph (ECG) signals were obtained through a spot electrode configuration, described by Qu, Zhang, Webster, and Tompkins (1986), and sampled at 1 kHz using a BioPac MP100 system (Goleta, CA). RSA was indexed by extracting the high frequency component (>.15 Hz) of the R-R time series using MindWare software (Mindware Technologies, Ltd., Gahanna, OH, USA). Electrocardiographic data were first collected during a 2 min resting baseline. Next, the research assistant re-entered the room and revealed the discussion topic. Adolescents and their mothers were instructed to maintain conversation for the full 10 min, and to limit unnecessary movement. Electrocardiographic data were collected during the entire discussion task, and change scores were calculated for each minute by subtracting the baseline score from the discussion task score. This enabled us to evaluate concordance between RSA reactivity and behavior across ten 1-min epochs. Although greater temporal resolution might be preferred, 1 min is often considered to be a minimum length for spectral analysis of high frequency heart rate variability (Berntson et al., 1997). Conversations were videotaped for behavioral coding.

5.4. Coding

The Family and Peer Process Code (FPPC; Stubbs, Crosby, Forgatch, & Capaldi, 1998) is a microanalytic behavioral coding system used to score dyadic behavior moment-to-moment. With the FPPC, raters assign a numerical code that represents the speaker, verbal behavior, and affect of each utterance. The code changes when there is a shift on any of these dimensions. The FPPC contains 25 content codes describing verbal behaviors, and 6 affect codes including 2 positive, 1 neutral, and 3 negative codes. Affect codes can be reduced into a 3-point scale (positive, neutral, negative). This results in a total of 25 content × 3 affect combinations. In order to examine aversiveness, we followed a strategy developed and validated by Snyder, Edwards, McGraw, and Kilgore (1994) and tested in a sample of adolescent females (Crowell, Baucom, et al., 2013). Each of the 75 codes (25 content × 3 affect) was reduced into a single number on a 10-point scale ranging from highly positive utterances (0) to coercive or attacking utterances (9).

Coding was conducted by two trained research assistants who received approximately 15 h per week of training on the FPPC following a multi-step process. First, coders were required to review the manual and become familiarized with the codes. Second, several tapes were reviewed and discussed code-by-code. Those tapes were acquired from other lab projects and had been scored in advance by the lead author. Third, the coders and lead author met and coded three criterion tapes as a group. Fourth, coders coded three additional criterion tapes without assistance, and discrepancies were discussed at the following meeting. Finally, coders were assigned three tapes per week including one shared tape—used to prevent observer drift and resolve coder disagreements. Coders were required to meet a minimum 10-key typing speed of 8000 keystrokes per hour with 95% accuracy. Reliability between coders was calculated on raw data (i.e., prior to collapsing into the 10-point scale). Consistent with published work (Snyder et al., 1994), reliability was $\kappa = .76$ for content and $\kappa = .69$ for affect. Coders were blind to study hypotheses and group status.

5.5. Analytic plan

Concordance between psychophysiology and behavior was conceptualized as within-epoch associations between RSA and aversiveness during the mother–daughter conflict discussion. As outlined above, the discussion was 10 min, which was subdivided into ten 1-min epochs. RSA reactivity (i.e., change scores) and mean aversiveness were modeled for each minute of the discussion. To examine concordance across psychophysiology and behavior both between and within dyad members, we used a multilevel actor-partner interdependence model (APIM; Kenny, Kashy, & Cook, 2006). We selected a multilevel approach because such models account for multiple forms of nesting (e.g., multiple measures from both mother and teen) and allow for unbalanced data including families with missing epochs. All analyses were conducted in HLM™, version 7.00 (Raudenbush, Bryk, & Congdon, 2011).

Actor-partner interdependence models are particularly advantageous for analyzing within- and between-person behavioral and physiological concordance, because they allow for simultaneous estimation of actor effects (e.g., effects of teen aversive behavior on teen RSA) and partner effects (e.g., effects of mother aversive behavior on teen RSA) for both family members. Including actor and partner effects in the same model allows for interpreting actor effects as representing an association within a dyad member, while accounting the same association between members and vice versa for partner effects. Additionally, APIM permits examination of between-family differences in concordance, so a single MLM can be used to test within-family effects (short-term concordance between aversive behavior and RSA within a given epoch), and between-family effects (i.e., differences in short-term concordance across families and group).

We followed procedures recommended by Kashy and Donnellan (2012) to create a two-intercept, repeated measures APIM model for distinguishable dyads by regressing each person's RSA change score onto her own aversive behavior within an epoch (the actor effect), the other family member's aversive behavior within an epoch (the partner effect), each family member's average aversive behavior across the entire conversation (to capture the overall tone of the relationship; Butler, 2011), group (−.5 = control, .5 = clinical), and the two-way and three-way interactions between aversive behavior within an epoch, average aversive behavior, and group (clinical vs. control) as illustrated in the following equations:

$$\text{Level 1}: \quad \text{RSA}_{ij} = \beta_{1j} * (\text{teen}) + \beta_{2j} * (\text{mom}) + \beta_{3j} * (\text{teen aversiveness actor})$$
$$+ \beta_{4j} * (\text{teen aversiveness partner}) + \beta_{5j} * (\text{mom aversiveness actor})$$
$$+ \beta_{6j} * (\text{mom aversiveness partner}) + r_{ij}$$

$$\text{Level 2}: \quad \beta_{ij} = \gamma_{i0} + \gamma_{i1} * (\text{teen avg. aversiveness}) + \gamma_{i2} * (\text{mom avg. aversiveness})$$
$$+ \gamma_{i3} * (\text{group}) + \gamma_{i4} * (\text{teen avg. aversiveness} \times \text{group})$$
$$+ \gamma_{i5} * (\text{mom avg. aversiveness} \times \text{group})$$

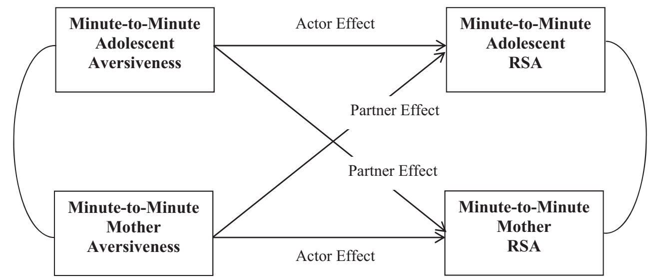

Fig. 1. Level 1 model examining minute-to-minute concordance between behavioral and physiological dysregulation.

with random effects, u_{1j} and u_{2j}, included on the intercepts for teen (β_{1j}) and mother (β_{2j}) respectively.[2] All Level-1 predictors were person-mean centered, and all continuous Level-2 predictors were grand-mean centered prior to creation of interaction terms and for analysis (Enders & Tofighi, 2007). Including average aversiveness and group at Level 2 allowed us to model how the overall tone of the relationship and group status affected Level 1 concordance, consistent with Butler (2011) review.

6. Results

The theoretical model we tested is depicted in Fig. 1. As illustrated, we modeled both the concordance of the emotional system within each person (actor effects) while simultaneously accounting for concordance across persons (partner effects). Two-way interactions test the Group × Minute-to-minute Aversiveness in predicting RSA. Three-way interactions test the Group × Minute-to-minute Aversiveness × Average Aversiveness on RSA. Although we could have constructed the reverse model (RSA predicting Aversiveness), we decided to predict RSA from behavior because participants can more easily observe one another's behavior than physiological responses. All statistical tests were conducted in a single model. Results from the full APIM are presented in Table 1.

6.1. Concordance between teen behavior and teen RSA: actor effect

The actor effect refers to within-person concordance of aversiveness and RSA while accounting for the effect of partner aversiveness on RSA. When predicting teen RSA, a significant three-way interaction emerged for Teen's Minute-to-minute aversiveness × Teen's Average Aversiveness × Group ($b = -0.08$, $p = 0.008$). To interpret this effect, the interaction was decomposed by computing simple slopes for both the control and clinical groups at one *SD* above the mean, at the mean, and at one *SD* below the mean of teen's average aversiveness (see Fig. 2). This revealed that teens in the clinical group who were more aversive (i.e., the most aversive depressed adolescents) showed a concordant moment-to-moment association between behavior and RSA. Specifically, there was a negative association between aversiveness and RSA within epochs—RSA decreased during epochs in which these teens became more aversive ($b = -0.08$, $p = 0.05$). In other words, the most aversive depressed teens were physiologically dysregulated when their behavior was also dysregulated. However, minute-to-minute aversiveness was not related to RSA change for less aversive depressed teens or for teens in the control group. Thus, teens who were less aversive did not evidence within-person concordance between physiology and behavior.

[2] The difference between actor and partner is depicted in Fig. 1, which illustrates the theoretical model tested by this formula.

Table 1
Results of actor-partner interdependence model.

Parameter	*B*	SE *B*	β
Teen intercept			
Teen × teen average aversiveness	−0.14	0.10	−0.26
Teen × mother average aversiveness	−0.04	0.12	−0.06
Teen × group	−0.15	0.18	−0.16
Teen × teen average aversiveness × group	0.14	0.11	0.22
Teen × mother average aversiveness × group	0.16	0.14	0.21
Teen momentary aversiveness actor effect	−0.03	0.03	−0.03
Teen momentary aversiveness actor effect × teen average aversiveness	0.04	0.02	0.05
Teen momentary aversiveness actor effect × mother average aversiveness	−0.05	0.04	−0.06
Teen momentary aversiveness actor effect × group	0.04	0.04	0.04
Teen momentary aversiveness actor effect × teen average aversiveness × group	−0.08**	0.03	−0.08
Teen momentary aversiveness actor effect × mother average aversiveness × group	0.03	0.04	0.03
Teen momentary aversiveness partner effect	0.15***	0.04	0.13
Teen momentary aversiveness partner effect × teen average aversiveness	0.02	0.03	0.02
Teen momentary aversiveness partner effect × mother average aversiveness	−0.12***	0.03	−0.12
Teen momentary aversiveness partner effect × group	−0.14**	0.05	−0.10
Teen momentary aversiveness partner effect × teen average aversiveness × group	−0.01	0.04	−0.01
Teen momentary aversiveness partner effect × mother average aversiveness × group	0.12**	0.04	0.10
Mother intercept			
Mother × teen average aversiveness	0.04	0.11	0.07
Mother × mother average aversiveness	−0.09	0.15	−0.13
Mother × group	−0.01	0.20	−0.01
Mother × teen average aversiveness × group	−0.02	0.13	−0.03
Mother × mother average aversiveness × group	0.06	0.17	0.08
Mother momentary aversiveness actor effect	0.03	0.05	0.03
Mother momentary aversiveness actor effect × teen average aversiveness	0.01	0.06	0.01
Mother momentary aversiveness actor effect × mother average aversiveness	0.08	0.06	0.08
Mother momentary aversiveness actor effect × group	−0.11*	0.06	−0.08
Mother momentary aversiveness actor effect × teen average aversiveness × group	−0.02	0.07	−0.02
Mother momentary aversiveness actor effect × mother average aversiveness × group	−0.05	0.08	−0.04
Mother momentary aversiveness partner effect	−0.01	0.03	−0.01
Mother momentary aversiveness partner effect × teen average aversiveness	−0.04	0.04	−0.05
Mother momentary aversiveness partner effect × mother average aversiveness	−0.08**	0.03	−0.10
Mother momentary aversiveness partner effect × group	0.01	0.04	0.01
Mother momentary aversiveness partner effect × teen average aversiveness × group	0.09	0.04	0.09
Mother momentary aversiveness partner effect × mother average aversiveness × group	0.11**	0.03	0.12

Note: Robust standard errors reported.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

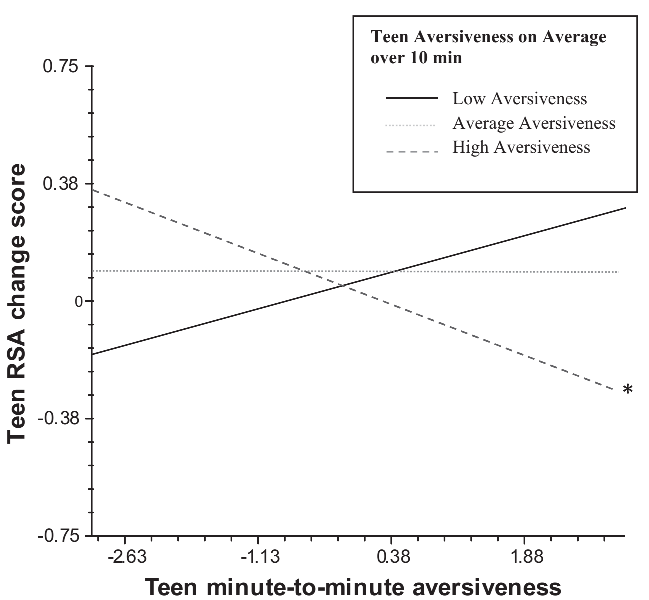

Fig. 2. Three way interaction of within-person concordance for adolescents in the clinical group. Adolescents who were most aversive across the 10 min interaction task showed a negative association between minute-to-minute aversiveness and RSA reactivity.

6.2. Concordance between mother behavior and mother RSA: actor effect

The actor effect for the mother is a test of within-person concordance between the mother's behavior and her own RSA. There was a significant two-way interaction for mother minute-to-minute aversiveness × group predicting mother RSA ($b = -0.11$, $p = 0.04$). Similar to the adolescents, mothers of depressed teens showed a negative association between aversiveness and behavior ($b = -0.09$, $p = 0.003$). Thus, clinical mothers showed expected within-person concordance between behavioral and emotional dysregulation, with RSA decreasing in epochs where their aversiveness increased. Control mothers, however, showed no minute-to-minute concordance between their behavior and their own RSA ($b = 0.03$, $p = 0.57$).

6.3. Concordance between mother behavior and teen RSA: partner effect

The partner effect predicts teen RSA from mother behavior. A significant three-way interaction emerged for mother minute-to-minute aversiveness × mother average aversiveness × group predicting teen RSA ($b = 0.12$, $p = 0.008$). This effect was decomposed as described above and is graphed in Fig. 3. This revealed that teens in the control group whose mothers were less

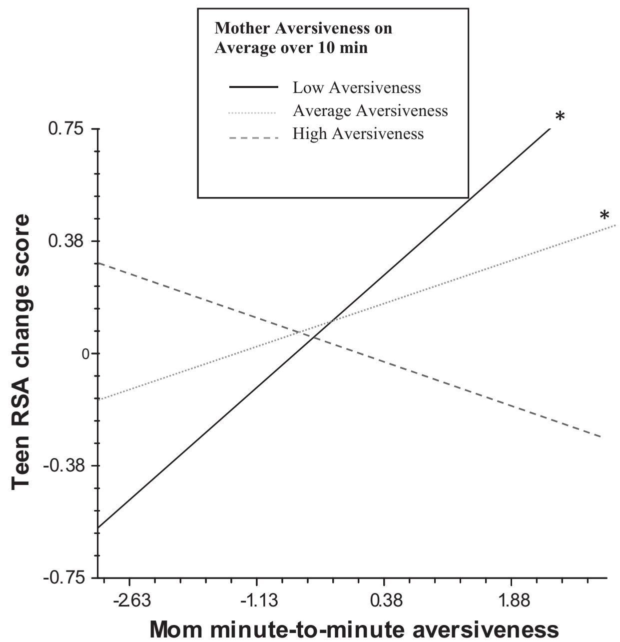

Fig. 3. Three way interaction of between-person concordance for adolescents in the control group. When mothers scored low or at the mean on overall aversiveness across the 10 min interaction task, their adolescents showed a positive association between minute-to-minute aversiveness and RSA reactivity.

aversive showed a concordant RSA response to their mother's aversiveness. However, as hypothesized, these teens showed RSA increases in epochs where their mothers became more aversive. This was true for control teens whose mothers scored low in aversiveness ($b = 0.33$, $p = 0.001$) or who were at the mean ($b = 0.15$, $p = 0.001$), but not for control teens whose mothers were highly aversive ($b = -0.02$, $p = 0.5$). There was no significant association between mother's minute-to-minute aversiveness and teen RSA change scores for the clinical group.

6.4. Concordance between teen behavior and mother RSA: partner effect

The partner effect for mother RSA is a test of how her physiology is affected by her teen's behavior. A significant three-way interaction emerged for teen minute-to-minute aversiveness × mother average aversiveness × group on mother RSA ($b = 0.11$, $p = 0.001$). Decomposition revealed that control mothers who scored low on aversiveness showed concordance between their daughter's behavior and their own RSA ($b = 0.10$, $p = 0.049$). As anticipated, as their daughters became more aversive, mother RSA increased, suggesting better regulation in the face of aversive teen behavior. However, for control mothers who were highly aversive, an unanticipated finding emerged. These mothers showed decreasing RSA to their daughter's aversive behavior ($b = -0.12$, $p = 0.013$), which we expected of clinical mothers. Fig. 4 illustrates concordant and discordant response patterns in clinical versus control participants.

7. Discussion

Developmental theorists assert that regulated and dysregulated behavior patterns emerge and persist within interpersonal relationships (Beauchaine & Zalewski, 2014; Granic, Hollenstein, Dishion, & Patterson, 2003; Hollenstein, Granic, Stoolmiller, & Snyder, 2004). In some families, angry and coercive interactions are negatively reinforced over time because they are the most effective means of getting one's needs met. These patterns often generalize to later peer and romantic relationships, contributing to interpersonal problems across development (Hughes et al., 2012; Kinsfogel & Grych, 2004). However, conflict is not necessarily problematic. In the context of a strong relationship, disagreement is an important step toward identifying and solving problems (Ubinger, Handal, & Massura, 2013). Thus, emotional responses to anger or aversiveness may differ as a function of a person's current emotional state, the nature of the relationship, and partner behavior in that moment.

Our findings revealed interesting patterns of concordance that were highly similar for mothers and daughters. In general, clinical participants showed physiological responses that tracked with their own behavior but not that of their partner. Furthermore, clinical participants generally showed the expected negative association between aversiveness and RSA. As behavior became more dysregulated, so did physiological responses. Control participants, on the other hand, had physiological response patterns that tracked with their partner's behavior but not their own. In addition, they evidenced a distinct pattern of concordance, where they became physiologically *more* regulated in the face of aversive partner behavior. Although this is a concordant response, most researchers would assume the simple hypothesis—physiological and behavioral dysregulation should co-occur. Interestingly, emotion researchers have often theorized that unexpected patterns may emerge due to regulatory strategies (see Hollenstein and Lanteigne, in this issue). However, there have been few studies that have examined whether this occurs naturally (i.e., regulation is not manipulated within the experiment) in response to complex social stimuli.

Decomposing these effects (see Figs. 2 and 3) revealed more subtle differences in concordance as a function of the average aversiveness of dyad members across the interaction. Our interest in this was informed by theories that families are a dynamic system in which current states are likely to be highly similar to past states (Butler, 2011). Some developmental researchers have described these as "attractor states." From this perspective, even though families could exhibit a limitless range of behavioral patterns, they often stabilize around a limited set of these possibilities (Granic & Hollenstein, 2003). We conceptualized average aversiveness as our index, albeit imperfect, of this phenomenon. Although best when measured dynamically, attractors can reflect "getting stuck" in certain states (see e.g., Hollenstein, Lichtwarck-Aschoff, & Potworowski, 2013). Such a phenomenon would be reflected in higher average aversiveness—revealing an important aspect of relationship quality.

As noted above, significant effects of average aversiveness were explored by examining differences between those who scored above, at, or below the mean. This allowed us to detect variability within group. For clinical dyads, only the most aversive depressed teens showed expected concordance between RSA and behavior—RSA decreases during minutes when they became more aversive. Post hoc examination of the data revealed that this was not due to combining self-injuring and non-injuring participants into a single depressed sample (i.e., highly aversive teens were not only self-injurers; Fischer's exact $\chi^2 = 6.416$, $p = .171$). This finding suggests that RSA decreases during stress were not a uniform response for depressed adolescents. Thus, some inconsistency in the literature on RSA and depression may be a function of variability within depressed samples (see Rottenberg, 2007 for a similar conclusion). One possibility is that RSA withdrawal to stress may only appear for depressed adolescents who are also dysregulated behaviorally.

Within the control group, there was also interesting variability. For teens whose mothers were less aversive, teen RSA increased with mother aversiveness. Similarly, in the same dyads where mothers were low on aversiveness, mother RSA increased in minutes when the teen became more aversive. This suggests that conflict may have provided an opportunity for self-regulation in dyads where the overall tone of the conflict was more positive. An

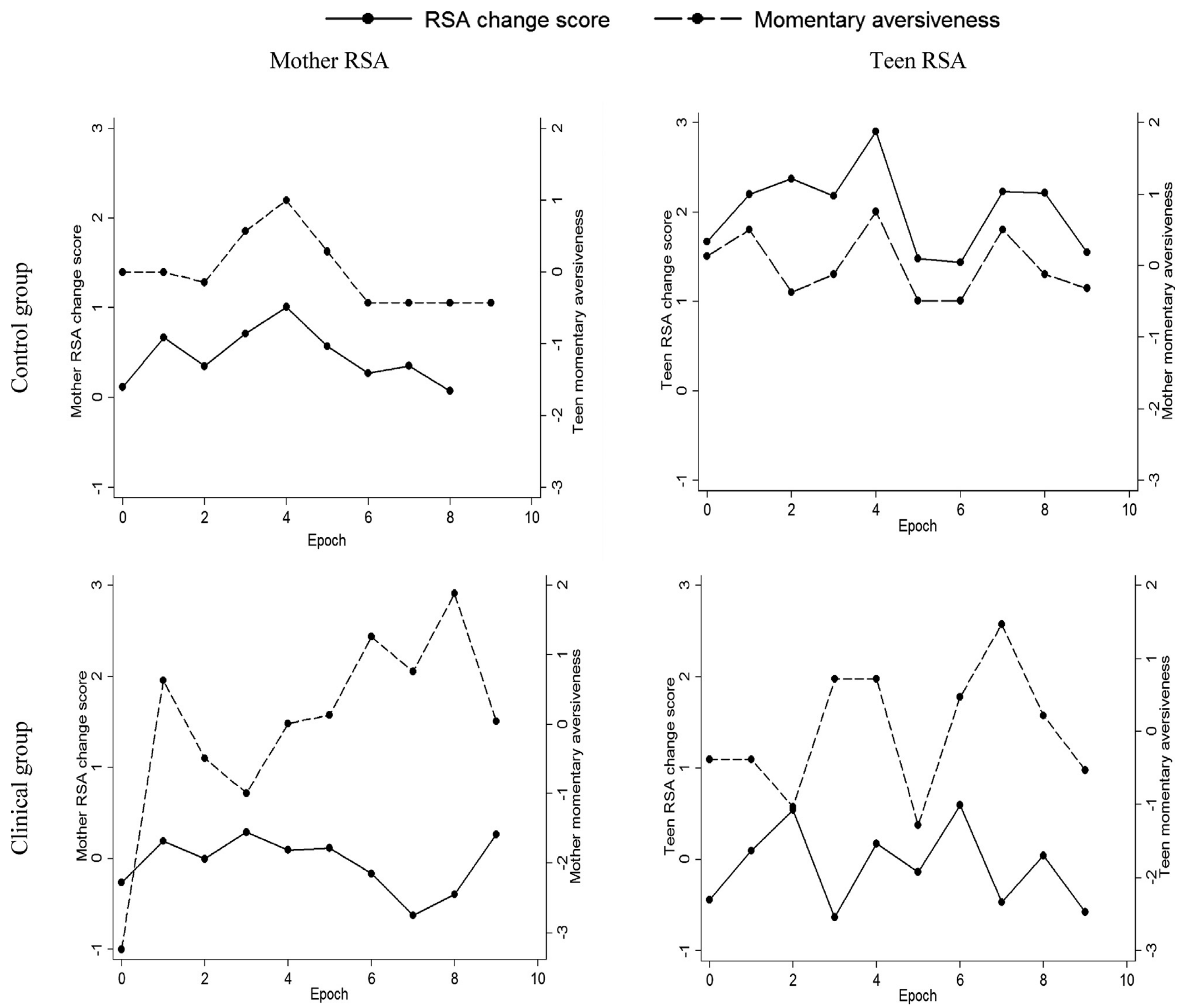

Fig. 4. Plots of minute-to-minute aversiveness and RSA change scores.

interesting effect emerged, however, for control mothers who were most aversive. These mothers showed an effect similar to mothers in the clinical group. In minutes when their adolescent became more aversive, their RSA decreased. Thus, control mothers who were dysregulated behaviorally were also more likely to become dysregulated physiologically when their adolescent was more aversive, which may be due to unmeasured maternal psychopathology or emotion dysregulation.

Findings from this study should be interpreted in the context of several limitations. We tested a complicated APIM that included both two- and three-way interactions. We chose this model because it is consistent with theories of concordance and because the approach provides a parsimonious means of controlling for between-person effects when assessing within-person concordance and vice versa. However, it is important to replicate these two- and three-way interactions in future research. As with most psychophysiological studies, our sample size was likely underpowered to detect all higher order interactions. Some authors suggest that sample sizes of 200–1000 would be required to ensure reliability and stability of findings (see Whisman & McClelland, 2005). In addition, our sample was all female and these results may not generalize to boys or fathers. Finally, our decision to combine self-injuring and depressed adolescents created a more heterogeneous depressed group and may have obscured some findings. We made an a priori decision to group clinical participants together in order to minimize the complexity of our statistical model and increase power to detect interactions. Self-injury and depression share features of emotion dysregulation and interpersonal distress and most studies of depression include similarly heterogeneous samples (e.g., Wilkinson, Kelvin, Roberts, Dubicka, & Goodyer, 2011). Thus, we did not hypothesize nor test for distinct concordance patterns between depressed adolescents with and without a history of self-injury.

Recently, there has been strong interest in understanding emotions in social contexts (Connell, Hughes-Scalise, Klostermann, & Azem, 2011; Helm et al., 2012; Skowron, Cipriano-Essel, Benjamin, Pincus, & Van Ryzin, 2013). When emotions occur while one is alone, traditional intrapersonal theories may apply. However, in intimate relationships and other social contexts, emotions might be better understood as dynamic interpersonal experiences (Lewis & Granic, 2000). Human emotions most often occur within such interpersonal contexts. This has motivated researchers to begin examining emotional experiences of dyads statistically (see Butler, 2011 for an extensive review). In light of this, it is important for theories of concordance to expand beyond individual response systems to incorporate dyads and larger social systems.

In addition to informing theories of emotion and concordance, these findings may also influence parenting research and intervention. Many treatments emphasize strategies for minimizing conflict between parents and children (e.g., Kastner & Wyatt, 2009). However, it is possible that reducing conflict is less important than teaching strategies to self-regulate during and after a fight. Persons with better self-control may be quicker to "repair" following conflict (e.g., apologize, joke, or solve the problem; see also Granic et al., 2007). Moreover, for some families, avoiding conflict may leave underlying problems unaddressed and unresolved. Future research should examine emotions in more naturalistic settings (e.g., home) and in the context of both conflict and reconciliation. Such work could reveal important differences not only in how families fight but how they come together.

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