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The Heart of Parenting: Parent HR Dynamics and Negative Parenting While Resolving Conflict With Child

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The current study examined parent heart rate (HR) dynamic changing patterns and their links to observed negative parenting (i.e., emotional unavailability and psychological control) during a parent–child conflict resolution task among 150 parent–child dyads (child age ranged from 6 to 12 years, M_{age} = 8.54 ± 1.67). Parent HR was obtained from electrocardiogram (ECG) data collected during the parent–child conflict resolution task. Negative parenting was coded offline based on the video recording of the same task. Results revealed that emotionally sensitive parents during the task showed greater HR increases while discussing a conflict and greater HR decreases while resolving the conflict, whereas emotionally unavailable parents showed no changes in HR. However, parent psychological control was not associated with HR dynamics during the task. These findings indicated the physiological underpinnings of parent emotional sensitivity and responsiveness during parent–child interactions. The potential association between HR baseline levels and parenting behaviors was also discussed.

Keywords: heart rate, parenting, emotional unavailability, dynamic, conflict resolution

Substantial evidence has demonstrated detrimental effects of negative parenting on children's psychosocial development in various cultures (Amato & Fowler, 2002; Whiteside-Mansell, Bradley, & McKelvey, 2009). In addition to corporal punishment and physical maltreatment, negative parenting in the emotional domain has raised increasing attention from researchers (Teicher & Samson, 2013). Studies have linked parents' emotionally abusive (e.g., hostility, psychological control) and neglectful (e.g., emotional unavailability) behaviors to a range of negative child outcomes including internalizing and externalizing problems as well as school maladjustment (e.g., Sturge-Apple, Davies, & Cummings, 2006). Therefore, it is critical to understand the antecedents or correlates of negative emotion-related parenting behaviors. Studies in this regard have been focused on parents' psychological characteristics such as depression (e.g., Lovejoy, Graczyk, O'Hare, & Neuman, 2000) and contextual factors such as socioeconomic status (e.g., Belsky, Bell, Bradley, Stallard, & Stewart-Brown, 2007). However, less attention has been directed to the psychophysiological underpinnings of negative emotion-related parenting.

Researchers have gradually realized the importance to examine biological factors such as gene, brain structure, hormone, and autonomic functioning to further understand parenting (Barrett & Fleming, 2011). Autonomic nervous system (ANS) functioning, particularly its control over cardiac activity indicated by heart rate (HR), respiratory sinus arrhythmia (RSA; indicating parasympathetic activity), and preejection period (PEP; indicating sympathetic activity), has been widely assessed in parenting studies because of the nonintrusive and less time-consuming nature of the measurement (e.g., Connell, Hughes-Scalise, Klostermann, & Azem, 2011; Manczak, McLean, McAdams, & Chen, 2015). However, findings from such studies have appeared inconsistent and sometimes contradictory. For example, some studies have linked HR elevation or RSA decreases in parenting context to high levels of parental sensitivity and low levels of intrusive parenting (e.g., Mills-Koonce et al., 2007; Moore et al., 2009), whereas other studies have found such patterns related to more harsh discipline (e.g., Lorber & O'Leary, 2005). The inconsistency may be due to differences in laboratory tasks, physiological indicators, and analytical methodologies across studies. Researchers have started to assess specific physiological measures in specific contexts and use time-series approaches to examine dynamic psychophysiological reactivity, as within-individual dynamic changes in physiological responses have been linked to behavioral and emotional adjust-

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ment (Butler, Wilhelm, & Gross, 2006; Cui et al., 2015). Therefore, the current study aimed to examine parents' HR dynamic changing patterns during a parent–child conflict resolution task and their associations to negative emotion-related parenting.

ANS Functioning and Parenting

Theoretical models of parenting have proposed specific neurobiological mechanisms regulating parental behaviors (Bridges, 2015). However, empirical studies have largely been focusing on general biological foundations supporting parental behaviors or trait-like neurobiological correlates of parenting (e.g., genotypes or brain functioning; Barrett & Fleming, 2011). Less is known regarding the role of physiological processes in organizing parenting behaviors during real-time parent–child interactions. The polyvagal theory (Porges, 2003, 2007) has indicated that ANS functioning is closely involved in the neurobiological regulation of emotional and behavioral processes in stress response or social interactions. Therefore, examining ANS functioning in parenting contexts, such as challenging or calm social interactions, and its association with parenting practices would further our understanding of the psychophysiology of real-time parenting behaviors.

ANS consists of sympathetic nervous system (SNS), which dominates the arousal processes in response to stress, resulting in HR increases, and parasympathetic nervous system (PNS), which typically inhibits SNS activation and down-regulates HR. Empirically, preejection period (PEP) and skin conductance levels (SCL) have been assessed to indicate SNS arousal, and respiratory sinus arrhythmia (RSA) has been used to indicate PNS activation (e.g., Berntson, Quigley, & Lozano, 2007). Based on the autonomic space model (Berntson, Cacioppo, & Quigley, 1991), SNS and PNS are not always reciprocal (e.g., Del Giudice, Hinnant, Ellis, & El-Sheikh, 2012; El-Sheikh et al., 2009). However, HR dynamic changes (fluctuations across time) usually reflect the relative dominance of SNS and PNS influence over the heart in response to constantly changing demands of both internal and external environments (Berntson et al., 1991; Fox, Kirwan, & Reeb-Sutherland, 2012).

Emerging evidence has documented the relationship between ANS functioning and parenting (e.g., Sturge-Apple, Skibo, Rogosch, Ignjatovic, & Heinzelman, 2011), particularly regarding PNS activity. For example, higher baseline RSA has been associated with greater parental sensitivity (Musser, Ablow, & Measelle, 2012). Mothers exhibited RSA increases while they were providing support for their children in face of challenges (Skowron et al., 2011). In contrast, studies have linked greater RSA decreases in response to infant cries or during stressful parent–child interactions (e.g., the reunion phase of the Still Face Paradigm) to less negative parenting (Mills-Koonce et al., 2009), higher levels of parental sensitivity (Joosen et al., 2013; Moore et al., 2009), and secure parent–child attachment (Hill-Soderlund et al., 2008). However, when considering the relative dominance of SNS or PNS influence, the relationship between parents' HR reactivity and parenting is less clear. Early evidence suggested that physical child abusers tend to experience greater HR increases when presented with child-related stimulus (see McCanne & Hagstrom, 1996 for a review). In contrast, elevated HR toward infant cries has been associated with maternal sensitivity, indicating the role of cardiac arousal in facilitating parental sensitivity (Joosen et al., 2013). In addition to such inconsistency regarding parents' HR reactivity to child-related cues and parenting, research is very limited concerning parental HR responses during real-time parent–child interactions. Lorber and O'Leary (2005) measured maternal HR during an interactive task designed to elicit children's rule-breaking behaviors, and found that greater HR increases were related to more harsh discipline. However, another study reported no association between parents' HR reactivity and their positive scaffolding behaviors or negation during parent–adolescent discussions about past challenging experience (Manczak et al., 2015). Taken together, more research is needed to clarify parental HR reactivity in parent–child interactions and its associations with specific parenting behaviors.

Understanding ANS Functioning in Contexts

Different laboratory tasks (e.g., infant cry, joint puzzle task) have been used in empirical studies, which may contribute to inconsistency in findings, no matter whether pure SNS or PNS functioning indicators or general ANS functioning indicators such as HR have been utilized. Researchers have pointed out the necessity to consider the context of measurement in psychophysiological studies (Cui et al., 2015; Schulkin, 2003). Indeed, the characteristics of laboratory stressors (e.g., stress levels, valence and intensity of the emotions elicited) may determine what kind of physiological reactivity could be observed, and what reactivity patterns are related to emotional and behavioral adjustment (Obradović, Bush, & Boyce, 2011). Therefore, it is important to consider the nature of parenting context and related parenting practices when interpreting the links between parenting behavior and psychophysiology (Mills-Koonce et al., 2009).

Indeed, researchers have proposed that parental physiological reactivity is adaptive and associated with effective parenting when it flexibly corresponds with real-time requirements of child rearing (e.g., Skowron, Cipriano-Essel, Benjamin, Pincus, & Van Ryzin, 2013). For example, HR elevation during stressful interaction with children may represent parents' active behavioral and emotional engagement, whereas HR down-regulation may imply emotional distance and avoidant attachment (Hill-Soderlund et al., 2008). In contrast, during less stressful interactions such as social engagement when regulatory processes are typically required (Porges, 2007), continuous cardiac arousal may be dysfunctional and associated with problematic parenting (Lorber & O'Leary, 2005). In ecologically valid parenting contexts, research has found that parents' initial HR increase to infant cries may support their emotional responsiveness toward infants' need for attachment (Joosen et al., 2013). On the other hand, maternal RSA increases have been observed during a mother–preschooler joint puzzle task, which may indicate their effort to remain calm and be supportively engaged (Skowron et al., 2011). However, more research is still needed to examine physiological reactivity during real-time parenting with children and adolescents in social contexts such as parent–child communication about emotional events or mutual conflicts (Manczak et al., 2015). Thus, the current study aimed to assess parent HR changing patterns during a conflict resolution task and their relationships with real-time parenting behaviors.

Dynamic ANS Responses and Parenting Context

Researchers have argued that switching between relative SNS and PNS dominance corresponding to being in and out of stressful condition is important for psychophysiological adaptation (e.g., Porges, 2007; Waugh, Panage, Mendes, & Gotlib, 2010). While linking psychophysiology and parenting, both physiological activation and recovery processes should be considered to match different conditions of parent–child interaction (Teti & Cole, 2011). Traditionally, averaged values of the indicator (e.g., HR, RSA, SCL) were typically calculated to summarize physiological responses across the laboratory task (e.g., El-Sheikh et al., 2009; Lorber & O'Leary, 2005). Recently, researchers argued that compared with the traditional approach of using a single mean index of physiological reactivity, a dynamic perspective of examining time-course physiological responses could better evaluate the adaptiveness of ANS functioning coupling with changing contextual requirements, particularly during ecologically valid real-time social interactions (Butler et al., 2006; Fox et al., 2012). In line with this argument, Giuliano, Skowron, and Berkman (2015) adopted a time-course approach to examine parental RSA dynamics across a parent–child joint puzzle task. They found that a flexible pattern of RSA decreases (in the beginning of the challenging task) followed by RSA increases (as the task continued) was associated with higher level of positive synchrony within the dyad.

In parenting context, such as conflict resolution in the current study, multiple phases corresponding with different stress levels are typically involved (e.g., the first phase is relatively stressful as they are discussing a mutual conflict, and the second phase is less stressful when they are figuring out solutions). As contextual requirements change across the two phases, psychophysiological functioning supporting parenting should match the changing demands. In stressful conflict discussion phase, it is natural and adaptive for parents to show dominant sympathetic arousal, whereas in less stressful conditions when parents are helping children search for conflict resolutions, dominant parasympathetic activation would be more adaptive to facilitate self-regulation and social engagement (Porges, 2007). To date, research has paid less attention to the second phase of social interaction. Empirical evidence has demonstrated that a timely HR recovery after exposure to a social stressor (e.g., public speech) is associated with flexible affective recovery (e.g., Waugh et al., 2010). There has also been evidence suggesting that parents' prolonged SNS arousal after the initial presence of infant cries is related to negative parenting behaviors (e.g., harsh discipline; Joosen et al., 2013). Thus, in the current study, it is more appropriate to adopt a dynamic approach to examine parent HR across the conflict resolution task in order to capture both HR increases corresponding to conflict discussion and HR recovery corresponding to solution search.

Parenting in Middle Childhood and Adolescence

When children reach middle childhood and adolescence, a series of changes in their cognitive capacity and social relationships may pose challenges for parents (Collins, Madsen, & Susman-Stillman, 2002). Research showed that, although children in middle-childhood and adolescence may spend less time with parents and demand increasing autonomy, they still expect parents to be available and supportive, particularly when they face challenges in life (Kerns, Tomich, & Kim, 2006). The mixed demands for autonomy and dependence may create further complications for parent–child relationship. Thus, parents of older children and adolescents usually face increasing stress and conflicts during parent–child interactions, and sometimes are more likely to be insensitive and controlling (Collins et al., 2002; Eisenberg et al., 2008). Negative parenting, particularly negative emotion-related parenting during this period typically leads to undesirable child outcomes such as internalizing and externalizing behaviors (e.g., Cui, Morris, Criss, Houltberg, & Silk, 2014). It is therefore important to study the correlates of negative parenting in middle childhood and adolescence.

The Current Study

Collectively, previous literature has indicated the importance of examining parents' dynamic physiological responses during parent–child interactions. The current study adopted a time-course approach to examine parental HR dynamics during a parent–child conflict resolution task, and aimed to test its relations with observed emotion-related parenting behaviors in the same task. Using a community sample, we focused on two forms of negative parenting practices that fall within the definition of emotionally neglectful and abusive behaviors (i.e., emotional unavailability and psychological control; Glaser, 2002).

We measured parents' HR reactivity and parenting behaviors during a parent–child conflict resolution task. This is an informative observational context where characteristics of child adjustment, parenting and parent–child relationships emerge during stressful conflicts or negotiation and collaborative solution-searching processes (Eisenberg et al., 2008). In the current study, parent–child dyads were instructed to first talk about disagreements or conflicts on a particular issue (Phase 1), and then try to come up with a consensual solution (Phase 2). Phase 1 was expected to be stressful as parent–child dyads recalled their conflicting experience on the issue and were potentially emotionally aroused. Phase 2 of the task might be less stressful and required parents to self-regulate and engage in active searching for solutions with their children. Therefore, we tested the following hypotheses: (a) parents would generally exhibit HR increases (relative SNS dominance) from the baseline to Phase 1 of the conflict resolution task and HR decreases (relative PNS dominance) from Phase 1 to Phase 2; and (b) a more variant HR dynamic pattern (i.e., greater HR elevation followed by greater HR decreases) would be related to lower levels of emotional unavailability and psychological control. We also explored whether the associations between parenting and parent HR dynamic changes varied based on child sex and age. However, no specific hypothesis was made in this regard due to lack of empirical evidence.

Method

Participants

Data were drawn from a larger research project focusing on family emotional processes and child adjustment. One-hundred and fifty parent–child dyads (121 biological mothers and 29 biological fathers who identified themselves as the primary caregivers in their families) from Beijing, China participated in the study.

Children's ages ranged from 6 to 12 years (M = 8.54, SD = 1.67, 87 boys and 63 girls), and all the children were attending primary schools. Parents' ages ranged from 25 to 59 years (M = 39.22, SD = 4.07). One-hundred and fourteen (76.0%) families in the sample have annual income higher than the average of the city (i.e., around $18,500 annually; National Bureau of Statistics of the People's Republic of China, 2015). Fifty (33.3%) parents completed graduate-level education, 91 (60.7%) held a college degree as the highest degree, and nine (6.0%) completed high school. Most parents (94.7%) reported married currently.

Procedures

This experiment and all study procedures were approved by the sponsoring university's Institutional Review Board. Participants were recruited via flyers distributed at local communities and online. Interested families were invited to visit the university laboratory. Children participated in a 2.5-hr assessment with one of their parents. Upon arriving at the laboratory, parents and children were informed of the purpose and procedures of the study and signed informed consent and minor assent forms. Following parental consent and child assent, they were hooked-up to physiological recorders and were given around 3 min to adapt to the equipment. Electrocardiogram (ECG) electrodes were attached to the participant's left leg (+), left arm (−), and right leg (ground), based on the Einthoven's triangle (Lead III; Biopac Systems, Inc.). The dyads then participated in a 2-min resting session where they were instructed to sit relaxed and breathe regularly without speaking or moving. Afterward, they completed several behavioral and interactive tasks including a 4-min parent–child conflict resolution task. Prior to the conflict resolution task, the participating parent and child rated the frequency of their daily disagreements or conflicts on 11 issues independently, for example, bed time, school performance, friend choice. Research assistant identified one issue that was rated highest in frequency by both the parent and the child. The dyads were given the following instructions for the discussion (the original instructions were in Chinese):

> I want you to spend some time on discussing one of your disagreements. Based on your ratings, you usually have conflicts on [the selected issue] in daily life. You will have 4 min to talk about this disagreement. I'd like you to discuss what this issue is about, how you feel about it, why it has become a source of conflict between you two, and then try to come up with a solution that you both agree on.

After giving the instructions, a research assistant reminded the parent and child to avoid drastic body movements during the discussion, particularly extremities where electrodes were attached to. The entire task was video recorded and the physiological measures of both parents and children were obtained. For the present study, we used parent ECG data during the resting session and the conflict resolution task. After the interactive tasks, the parent and the child each completed a packet of questionnaires in separate rooms.

Measures

Parent–child conflict issues. A Family Conflict Checklist, which consisted of 11 issues covering different aspects of children's life, for example, watching TV, school or academic performance, friend choices, was rated independently by the parent and child. They rated the frequency of disagreement or conflict on each issue on a 3-point Likert scale (ranging from 1 = *never* to 3 = *very often*). Average scores were calculated for parents and children, respectively. Cronbach's alpha was .68 for parent ratings and .64 for child ratings.

Emotion-related parenting behaviors. Parenting behaviors were coded based on the video recordings of the conflict resolution task. Macrocoding was adopted so that the parental behaviors of interest could be examined in larger context, and be evaluated synthesizing the entire process of conflict resolution (Lindahl, 2001). A parent–child interactions coding system was translated and adapted for the current study (Minnesota Longitudinal Study of Parents and Children, n.d.). The manual provided detailed description and examples of each parenting behavior and each score in specific parenting scales. Trained research assistants independently coded the task, taking notes on the amount and characteristics of specific types of parenting behaviors, and giving a score for each type of parenting behaviors across the task for each parent. Ten percent of the video recordings were randomly selected and double coded. Intercoder reliability coefficients were calculated.

Emotional unavailability. The Emotional Unavailability Scale reflected the extent to which a parent failed to be aware of or respond appropriately to the child's emotional needs. Coders used a 7-point Likert scale. Parents who scored low (e.g., 1) on this scale exhibited sensitive awareness and appropriate responses to the child's emotional experience (e.g., labeling, validating, expressing curiosity or empathy to the child's emotions, being able to comfort a distressed child). Parents who scored high (e.g., 7) on this scale appeared to be unavailable to the child's emotional needs or detached from the interaction (e.g., ignoring or showing impatience to the child's emotional expressions or bids for attention, not being able to comfort a distressed child or share the child's positive experience, only interacting with the child when necessary or required to by the task). Interrater reliability for emotional unavailability was .90.

Psychological control. The Psychological Control Scale measured the extent to which the parent failed to recognize the child's individuality and attempted to control the child's opinions, ideas, and feelings. It was coded on a 7-point Likert scale. Parents who scored low (e.g., 1) on this scale did not show any attempt to coerce or squash the child's own ideas, opinions, and feelings, whereas parents who scored high (e.g., 7) on this scale attempted to align the child with their own perspective through psychological controlling approaches (e.g., eliciting guilt or shame, derision, coercion, and threats of love withdrawal). Salient indicators of psychological control also included intrusive interruptions when the child was speaking and pointing out the inadequacy of the child's opinions without explaining or offering alternative options. Interrater reliability for psychological control was .89.

Heart rate. Parent ECG was recorded during both the resting session and the conflict resolution task. After the consent procedure, we used a 16-channel physiological recorder (BIOPAC MP150, Biopac Systems Inc., Santa Barbara, CA) to monitor and record continuous ECG signals. The amplifier gain was set to 2000, with the high-pass filter at 0.5 Hz, the low-pass filter at 35 Hz, and the sample frequency at 1000 Hz. ECG data were imported to the MindWare HRV 3.1.1 program (Mindware Technologies, Ltd., Gahanna, OH) and every 30-s epoch of the resting session and conflict resolution task were calculated. HR values of resting session were later averaged to generate a baseline HR level for each parent. ECG artifacts (wrongly identified or missed heartbeats) due to motor activity or signal disturbance were edited through visual checks and manual corrections in MindWare program prior to HR calculation. HR values for 9.2% of total epochs were missing, mainly due to equipment failure, poor signal quality, or research assistant errors. Missing data were handled in HLM 6 software (Scientific Software International, Inc., Skokie, IL) using restricted maximum likelihood estimation during multilevel modeling.

Analytic Strategy

The present study aimed to investigate parents' dynamic HR reactivity during conflict resolution with their children, and the relations between HR dynamics and negative parenting. We adopted multilevel modeling to examine the time course dynamics (i.e., linear and quadratic changes) of parent HR and its association with observed emotional unavailability and psychological control. The model was tested in HLM 6 software with parent HR as the outcome variable (Raudenbush, Bryk, Cheong, Congdon, & du Toit, 2004). Time was coded as 0 for HR baseline and 1–8 for HR values across the task. Linear and quadratic time variables were entered at Level 1 as within person (or dyad) parameters. Parenting variables, child sex (originally coded as 0 = male, 1 = female), parent sex (originally coded as 0 = mother, 1 = father), and child age were standardized, and interaction terms of child sex and parenting, child age and parenting were created with the standardized scores. Parenting variables, child sex, age, parent sex, and the interaction terms were then entered at Level 2 as between-person (or dyads) variables (similar to Cui et al., 2015; Giuliano, Skowron, & Berkman, 2015).

First, we tested the overall parent HR dynamic changes from the baseline through the conflict resolution task, controlling for parent sex, child sex and age. The coefficients of linear (b_1) and quadratic (b_2) time variables represent the patterns of HR dynamic changes. Next, parent emotional unavailability and psychological control, and interactions of parenting and child sex and age were entered at Level 2 to predict baseline HR (b_0) and HR linear (b_1) and quadratic changes (b_2). Nonsignificant interaction terms were trimmed for the final models.

Level 1:

$$HR = b_0 + b_1 Time + b_2 Time^2 + \varepsilon$$

Level 2:

$$b_0 = \gamma_{00} + \gamma_{01}\,Child\ Sex + \gamma_{02}\,Child\ Age + \gamma_{03}\,Parent\ Sex + \gamma_{04}\,Parenting + \gamma_{05}\,Parenting \times Child\ Age + \gamma_{06}\,Parenting \times Child\ Sex + \upsilon_0$$

$$b_1 = \gamma_{10} + \gamma_{11}\,Child\ Sex + \gamma_{12}\,Child\ Age + \gamma_{13}\,Parent\ Sex + \gamma_{14}\,Parenting + \gamma_{15}\,Parenting \times Child\ Age + \gamma_{16} Parenting \times Child\ Sex + \upsilon_1$$

$$b_2 = \gamma_{20} + \gamma_{21}\,Child\ Sex + \gamma_{22}\,Child\ Age + \gamma_{23}\,Parent\ Sex + \gamma_{24}\,Parenting + \gamma_{25}\,Parenting \times Child\ Age + \gamma_{26}\,Parenting \times Child\ Sex + \upsilon_2$$

Results

Descriptive Analysis and Correlations

Means, standard deviations, and bivariate correlations of all focal variables are presented in Table 1. T tests were conducted to examine sex differences on study variables. Overall, parents

Table 1
Means, Standard Deviations, and Correlations Among Studied Variables

Variable	N	M	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Child sex[a]	150	.42	.50																
2. Child age	150	8.54	1.67	.00															
3. Parent sex[b]	150	.19	.40	−.07	.15$^{\#}$														
4. Parent CF	147	1.67	.29	.06	.11	−.07													
5. Child CF	147	1.61	.32	.08	.01	.03	.35**												
6. EU	150	3.32	1.32	−.04	−.03	.01	.18*	.27**											
7. PC	150	2.58	1.43	.03	−.16*	−.20*	.20*	.31**	.33**										
8. HR BL	143	76.40	8.50	.17*	−.00	.06	.11	.08	.16$^{\#}$	.15$^{\#}$									
9. HR CR1	139	77.15	8.64	.19*	.03	.06	.01	.03	.07	.08	.88**								
10. HR CR2	140	77.23	8.72	.19*	.00	.05	.05	.06	.11	.14	.91**	.95**							
11. HR CR3	140	77.27	8.79	.17*	.03	.03	.08	.07	.07	.10	.92**	.93**	.96**						
12. HR CR4	138	77.26	8.60	.19*	.05	.06	.05	.03	.08	.13	.90**	.92**	.94**	.96**					
13. HR CR5	136	77.22	9.08	.19*	.10	.05	.05	−.00	.03	.13	.88**	.91**	.93**	.94**	.95**				
14. HR CR6	134	77.06	9.19	.17*	.07	.03	.08	.08	.11	.15	.89**	.90**	.93**	.94**	.94**	.95**			
15. HR CR7	132	77.43	8.69	.19*	.08	.06	.05	.01	.05	.11	.89**	.91**	.94**	.95**	.96**	.95**	.95**		
16. HR CR8	124	76.76	8.95	.22*	.04	.14	.04	.00	.06	.13	.89**	.93**	.94**	.95**	.95**	.95**	.94**	.95**	
17. Mean HR CR	140	77.22	8.58	.20*	.04	.05	.06	.06	.08	.12	.92**	.96**	.97**	.98**	.98**	.97**	.97**	.98**	.98**

Note. EU = emotional unavailability; CF = conflict frequency; PC = psychological control; HR = heart rate; BL = baseline; CR1 to CR8 = the first to the eighth 30-second epoch of the conflict resolution task.
[a] Child sex was coded as 0 (male) and 1 (female). [b] Parent sex was coded as 0 (mother) and 1 (father).
$^{\#}p < .07$. $^{*}p < .05$. $^{**}p < .01$.

exhibited low to medium levels of emotional unavailability and psychological control. Parent- and child-reported daily conflict frequencies were significantly correlated with each other. Parents were more likely to be emotionally unavailable and to adopt psychologically controlling behaviors when the parent or the child reported more conflicts between them. Higher levels of psychological control were observed among parents of younger children (see Table 1), and also among mothers compared to fathers, $t(59) = 3.06$, $p = .003$. We also divided children into two groups based on age, young children (6- to 9-year-olds) and early adolescents (10- to 12-year-olds), and found that parents of older children reported more daily conflicts, $t(77) = -2.37$, $p = .02$.

Parent HR levels were correlated with each other across the resting session and the 4-min conflict resolution task. Parents of girls exhibited higher levels of HR baseline, $t(131) = -2.06$, $p = .04$, and across the task (test statistics were similar to that at baseline). Neither parent-reported nor child-reported conflict frequency was significantly associated with parent HR levels. Marginally significant positive correlations were observed between baseline HR and both forms of negative parenting. However, parents' mean HR across the conflict resolution task was not associated with conflict frequency or parenting behaviors (see Table 1).

HR Dynamic Changes and Parenting Behaviors

We found that overall parents showed HR increases from the baseline to the first half of the task, $b_1 = 0.38$, $p = .001$, followed by HR decreases toward the end of the task, $b_2 = -0.04$, $p = .001$. Parents of girls exhibited higher levels of baseline HR compared to parents of boys, $\gamma_{01} = 1.52$, $p = .03$. Parents of older children experienced greater HR increases during the first half of the task, $\gamma_{12} = 0.28$, $p = .02$, and greater HR decreases during the second half of the task, $\gamma_{22} = -0.03$, $p = .02$. Estimation of pseudo-R^2 (Singer, 1998) showed that the linear and quadratic time variables accounted for 15.7% of the within-person variance in HR.

Results of models with parenting behaviors as predictors at Level 2 are presented in Table 2. Parent emotional unavailability was significantly associated with parent HR dynamic reactivity, $\gamma_{14} = -0.26$, $p = .02$; $\gamma_{24} = 0.03$, $p = .03$ (see Figure 1). The interaction of child sex and parenting was not significant in predicting either the HR linear or the quadratic changes. However, the interaction of child age and emotional unavailability was significant in predicting HR linear and quadratic changes, $\gamma_{15} = -0.37$, $p = .001$; $\gamma_{25} = 0.03$, $p = .003$ (see Table 2). Further probing of the interaction effects revealed that the relations between emotional unavailability and HR linear and quadratic changes started to be statistically significant when children were 8 years old and older. In other words, parents who showed an increase and sub-

Table 2
Multilevel Models of the Associations Between HR Dynamic Changes and Negative Parenting

Fixed effect	Model 1 emotional unavailability			Model 2 psychological control		
	Coefficient	*SE*	*t*	Coefficient	*SE*	*t*
b_0 (HR baseline)						
γ_{00} (Intercept)	**76.58****	.68	113.29	**76.61****	.67	113.68
γ_{01} (Child sex)	**1.53***	.69	2.22	**1.48***	.68	2.17
γ_{02} (Child age)	−.12	.64	−.20	−.00	.65	−.00
γ_{03} (Parent sex)	.76	.79	.95	.98	.79	1.24
γ_{04} (Parenting)	**1.21**$^{\#}$	.65	1.86	**1.20**$^{\#}$	.62	1.92
γ_{05} (Parenting × Child Age)	−.36	.59	−.61	—	—	—
b_1 (HR linear change)						
γ_{10} (Intercept)	**.35****	.10	3.53	**.38****	.11	3.47
γ_{11} (Child sex)	−.08	.10	−.79	−.03	.11	−.31
γ_{12} (Child age)	**.25***	.11	2.30	**.28***	.14	2.07
γ_{13} (Parent sex)	−.10	.10	−1.03	−.10	.10	−1.06
γ_{14} (Parenting)	**−.26***	.11	−2.36	.02	.11	.22
γ_{15} (Parenting × Child Age)	**−.37****	.10	−3.48	—	—	—
b_2 (HR quadratic change)						
γ_{20} (Intercept)	**−.04****	.01	−3.53	**−.04****	.01	−3.49
γ_{21} (Child sex)	.01	.01	1.15	.01	.01	.69
γ_{22} (Child age)	**−.03***	.01	−2.15	**−.03***	.01	−1.97
γ_{23} (Parent sex)	.02	.01	1.67	.02	.01	1.76
γ_{24} (Parenting)	**.03***	.01	2.20	−.00	.01	−.01
γ_{25} (Parenting × Child Age)	**.03****	.01	3.03	—	—	—

Random effect	Variance Component	· $\chi^2(df)$	*p*	Variance Component	· $\chi^2(df)$	*p*
υ_0 (HR baseline)	64.97	2915.97 (134)	.000	64.55	2925.88 (135)	.000
υ_1 (HR linear)	.50	190.41 (134)	.001	.69	218.43 (135)	.000
υ_2 (HR quadratic)	.00	152.49 (134)	.131	.00	170.71 (135)	.020
Level 1 error, ϵ	4.58			4.60		

Note. HR = heart rate. Level 2 variables were standardized. Statistically significant or marginally significant coefficients were indicated in bold.
$^{\#}p < .07$. $^{*}p < .05$. $^{**}p < .01$.

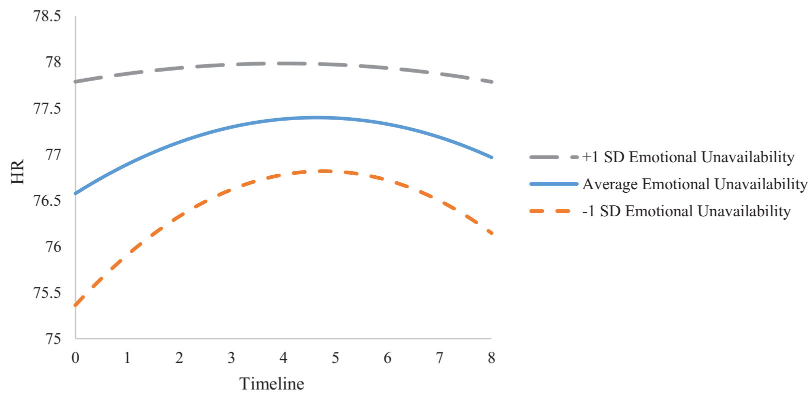

Figure 1. Parent heart rate (HR) dynamics as a function of parent emotional unavailability. 0 = baseline; 1–8 = the first to eighth 30-s epoch during conflict resolution; *SD* = standard deviation. See the online article for the color version of this figure.

sequent decrease of HR in response to the conflict resolution process tend to be more sensitive and responsive to children's emotional needs, and this association was stronger among parents of older children. Estimation of pseudo-R^2 showed that the full model of emotional unavailability (see Model 1 in Table 2) explained 32.7% of the variance in HR linear change and 41.7% of the variance in HR quadratic change. However, psychological control was not significantly associated with HR dynamic changes across the task.

Discussion

The primary goal of this study was to examine parent HR dynamic changing patterns during the conflict resolution processes with their children, and to explore their relations to real-time negative emotion-related parenting. Multilevel models were utilized to test the time-course changes of parental HR and whether they were associated with parent emotional unavailability and psychological control. We found that a pattern of HR increases followed by HR decreases in response to stressful parent—child interaction may be more adaptive in supporting parents' emotional sensitivity and responsiveness. Our study extended previous literature on the organization and regulation of parental behaviors by revealing the real-time associations between physiological adaptation to parenting context and effective parenting practice. The current findings also inform practical efforts that facilitating flexible physiological regulation might be a feasible way to reduce negative parenting behaviors.

HR Dynamics and Negative Parenting Behaviors

Based on our time-course analysis, a pattern of HR elevation during the stressful conflictive interaction (Phase 1) followed by HR reduction during the collaborative solution-seeking discussion (Phase 2) was observed in parents. This finding is consistent with the allostasis framework (Schulkin, 2003), which has posited that physiological flexibility in accord with contextual demands represents a fundamental mechanism of adaptation. In the current study, HR increases from baseline to Phase 1 may indicate emotional arousal required by the conflictive interaction. HR decreases from Phase 1 to Phase 2, however, may suggest a shift toward relative PNS dominance and represent parents' active coping and regulatory effort as they engage in cooperative communication (Porges, 2003). Taken together, the HR increase at the beginning of the task and the down-regulation during the second half of the task may have served as physiological resources for parents' emotional and behavioral adaptation to support specific parenting needs in this particular conflict resolution context.

Emotional unavailability. Emotional unavailability reflects parents' insensitivity to child emotional needs and psychological detachment from parent–child interactions (Biringen & Robinson, 1991). In the current study, we found that the emotionally unavailable parents showed no HR reactivity from baseline through the conflict resolution task, whereas emotionally available parents showed a pattern of HR increases during the initial conflictive discussion and HR recovery in the resolution phase. Our results are consistent with previous findings linking parents' dampened PNS reactivity during stressful parent–child interactions with insensitive parenting (e.g., Moore et al., 2009), and are also consistent with a neurophysiological study showing that emotionally available mothers experienced a shift toward greater right frontal brain activation when listening to infant cries (indicating empathetic processes; Killeen & Teti, 2012). Parents' dampened HR responses might indicate a lack of awareness and empathy toward the children's emotional dynamics during the interaction. Additionally, the physiological insufficiency may have rendered the parents unable to respond sensitively to their children's emotional needs, even if they are aware of the children's emotional experience. Previous studies have found that depletion of psychological resources or failure to direct the resources to children's emotional needs may underlie parents' emotional unresponsiveness (Danner-Vlaardingerbroek, Kluwer, van Steenbergen, & van der Lippe, 2013). Our results further suggest that the lack of physiological resources (indicated by blunted HR responses) may underlie parents' emotional unavailability in moderately stressful parent–child interactions.

We also found that the association between blunted HR reactivity and emotional unavailability was stronger for parents of older children. Consistent with previous evidence showing that more parent–child conflicts emerge when children approach early adolescence (e.g., Burt, McGue, Krueger, & Iacono, 2005), in the current sample, parents of preadolescent children reported more daily conflicts compared to parents of younger children. As children age, parents are required to make adjustments in parenting. Among parents of older children with higher demands for emotional and behavioral engagement and regulation in conflictive situations, physiological responsivity may be more important to facilitate effective parenting.

Psychological control. We did not find significant associations between observed parent psychological control and HR dynamics. Previous studies have linked parental emotional disturbance to the use of psychological control (Aunola, Ruusunen, Viljaranta, & Nurmi, 2015). However, few studies have tested the association between physiological processes and intrusive and manipulative behaviors directed to children's feelings and thoughts. As the violation of children's individuality stands in the core of psychological control, it is possible that this type of parenting behavior is directly derived from negative cognitions or parenting attitudes (Rudy & Halgunseth, 2005) such as maladaptive socialization goals (Wang, Chan, & Lin, 2012). Therefore, the use of psychological control might be less closely related to real-time emotional or physiological responses. Moreover, a study found that psychological control was less strongly associated with parents' maladaptive cognitions or emotions for collectivist groups compared with noncollectivist groups (Rudy & Halgunseth, 2005). The null findings among the current Chinese sample may due to cultural differences. More research is needed to examine the emotional and physiological foundation of parental psychological control, particularly across different cultures.

HR baseline and negative parenting. Additionally, we observed marginally significant associations between higher levels of baseline HR and both forms of negative parenting. This is consistent with previous evidence linking higher HR at resting states to maternal insensitivity (Joosen et al., 2013). HR level is influenced by the two branches of ANS, and both hyperarousal in the SNS and hypoactivity in the PNS may contribute to heightened baseline HR. Reduced PNS activity in resting states has been posited as an indicator of poor regulatory potential (Beauchaine, 2001), and parents' low baseline RSA (suggesting high baseline HR) has been empirically linked to insensitive parenting and less positive affect during parent–child interactions (Connell et al., 2011; Musser et al., 2012). Researchers also suggested that high SNS baseline activity could be related to increased vulnerability to psychopathology (e.g., El-Sheikh et al., 2009). Therefore, heightened baseline HR might be related to parents' own psychological or physiological maladjustment, and thus associated with emotionally neglectful and manipulative parenting.

Strengths, Limitations, and Implications

In summary, the current study made one of the first attempts to explore the associations between real-time physiological reactivity and parenting by examining parents' HR dynamics across an ecologically valid interaction with their children. We investigated the links between HR dynamics and parenting using a community sample, extending research of parenting and psychophysiology from studying families with maltreating parents to a wider range of families. Theoretically, the current study advanced the existing literature by providing evidence of the associations between physiological responses and specific parenting behaviors in the emotional domain. Methodologically, our findings suggest that time-course approach may be more appropriate than traditional approach in capturing psychophysiological dynamics corresponding to constantly changing contextual requirements (Cui et al., 2015; Teti & Cole, 2011).

There are also some limitations of the current study. First, although the current study employed objective physiological and observational measures, future research could incorporate subjective reports of parent emotions and behaviors to provide a more complete picture of parenting. Second, we only used a single physiological indicator. HR reactivity reflects the relative dominance of SNS and PNS influence over the heart (Berntson et al., 1991), but could not capture profiles of the two branches (e.g., coactivation, coinhibition, or coordination; Del Giudice et al., 2012). Recent studies have pointed out that, while working jointly, SNS and PNS also play their unique roles in supporting parenting behaviors (Hill-Soderlund et al., 2008). Examining multiple indicators of ANS functioning and even different physiological systems is helpful for future research on this topic. Additionally, the current study did not control for potential confounding factors such as motor activity and amount of talking, which are thought to influence respiration rate and thus estimates of RSA (Grossman, Karemaker, & Wieling, 1991). Third, the exact time spent on talking about conflicts (Phase 1) and finding solutions (Phase 2) were up to the parent–child dyads rather than being preset by researchers. There might be variations in parenting behaviors due to the timing of conflict and resolution during the interaction. Additionally, although such tasks reflect the natural dynamics of interaction and are ecologically valid (e.g., Cui et al., 2015; Giuliano et al., 2015), the arbitrary distinction of two phases is not ideal for analyzing physiological responses. Finally, the majority of our sample comprised of well-educated, higher income, and intact Chinese families. One should be cautious to generalize the findings to other social and cultural groups.

Despite these limitations, the current study has provided evidence regarding the association between blunted HR responses and emotionally insensitive and unresponsive parenting behaviors. In the future, researchers could further explore the developmental mechanisms of negative parenting (e.g., the mediating role of physiological dysregulation in the relations between contextual or psychological risk factors and problematic parenting). Moreover, efforts should be made to include a wider range of parenting behaviors in studying the psychophysiology of parenting, for example, positive parenting processes. Additionally, future research can benefit from considering the contexts of parenting and physiological measures, and using a time-series approach to examine whether physiological responses predict concurrent or subsequent parenting behaviors during real-time interactions with children (e.g., Skowron et al., 2013). Findings of the current study can also inform prevention and intervention practitioners. For example, they could include physiological indicators while examining the effectiveness of prevention and intervention programs focusing on promoting parents' emotional responsivity or positive parenting.

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