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Regular Article

Mothers' and fathers' self-regulation capacity, dysfunctional attributions and hostile parenting during early adolescence: A process-oriented approach

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Abstract

The parent-child relationship undergoes substantial reorganization over the transition to adolescence. Navigating this change is a challenge for parents because teens desire more behavioral autonomy as well as input in decision-making processes. Although it has been demonstrated that changes in parental socialization approaches facilitates adolescent adjustment, very little work has been devoted to understanding the underlying mechanisms supporting parents' abilities to adjust caregiving during this period. Guided by self-regulation models of parenting, the present study examined how parental physiological and cognitive regulatory capacities were associated with hostile and insensitive parent conflict behavior over time. From a process-oriented perspective, we tested the explanatory role of parents' dysfunctional child-oriented attributions in this association. A sample of 193 fathers, mothers, and their early adolescent (ages 12–14) participated in laboratory-based research assessments spaced approximately 1 year apart. Parental physiological regulation was measured using square root of the mean of successive differences during a conflict task; cognitive regulation was indicated by set-shifting capacity. Results showed that parental difficulties in vagal regulation during parent-adolescent conflict were associated with increased hostile conflict behavior over time; however, greater set-shifting capacity moderated this association for fathers only. In turn, father's dysfunctional attributions regarding adolescent behavior mediated the moderating effect. The results highlight how models of self-regulation and social cognition may explain the determinants of hostile parenting with differential implications for fathers during adolescence.

Keywords: adolescence, attributions, fathers, parenting, self-regulation

Parent-child conflict is a hallmark of the adolescent period and serves as an important context for parental socialization during this developmental stage (Martin, Sturge-Apple, Davies, & Romero, 2017; Smetana, Campione-Barr, & Metzger, 2006). Navigating conflict discussions is a challenge for parents during the transition to adolescence because teens desire more behavioral autonomy as well as input in decision-making processes. Consistent with this, parents must flexibly adjust their parenting behaviors to support these developmental changes in their relationship with their child. Although it has been demonstrated that adaptations in parenting facilitate adolescent adjustment (Paulson & Sputa, 1996), very little work has been devoted to understanding the underlying mechanisms supporting parents' abilities to adjust caregiving during this period. Emerging conceptual frameworks of parental self-regulation in the context of stressful parent-child interactions provide a useful heuristic for generating research questions of interest (Deater-Deckard & Sturge-Apple, 2017). Within these conceptualizations, interactive processes across cognitive and physiological domains provide support to parents with respect to behavioral regulation and adjustment of their intended socialization goals (Crandall, Deater-Deckard, & Riley, 2015). In particular, both the stress response system and executive functions have been implicated as key dimensions in self-regulation (Hofman, Schmeichel, & Baddeley, 2012) with important regulatory effects on caregiving (Deater-Deckard & Bell, 2017).

Empirical work has demonstrated the potential for models of self-regulation to inform caregiving processes (e.g., Deater-Deckard & Bell, 2017; Sturge-Apple, Jones, & Suor, 2017); however, scant work has tested these conceptualizations during adolescence and the examination of these processes in fathers is virtually absent in the literature. To address these gaps, the present study examined how mothers' and fathers' physiological regulation in the context of parent-adolescent discipline was associated with their use of harsh and insensitive conflict behaviors over time. Harsh discipline is reflective of overreactive forms of nonempathetic, power-assertive, and hostile discipline methods (Lorber & O'Leary, 2005), and exposure to harsh discipline has been associated adolescents' poorer psychological and school adjustment (Branje, van Doorn, van der Valk, & Meeus, 2009; Weymouth, Buehler, Zhou, & Henson, 2016). At the cognitive level, we further tested how a domain of the executive function suite, set-shifting capacity, may operate as an individual difference factor in moderating associations between physiological regulation difficulties and

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parental harsh discipline. From a process-oriented approach, we also tested whether parental attributions of their adolescent's behavior may operate as a mediating mechanism underlying this moderating effect.

Vagal regulation and caregiving

The autonomic nervous system (ANS) is a primary determinant of psychological arousal and as such is implicated in a number of specific processes including goal-directed behavior, adaptability, emotion regulation, and homeostatic regulation (Porges, 2001). A component of the ANS, the parasympathetic nervous system (PNS) is known to play an important role in regulating physiological responses and developing and modulating social behaviors (Porges, 2001). Respiratory sinus arrhythmia (RSA) reflects PNS activity via vagal nerve activity, which serves to suppress heart rate below its intrinsic rate (Porges, 2001). Broadly, RSA is believed to be integral to an individual's capacity to regulate emotions in social situations (e.g., Butler, Wilhelm, & Gross, 2006). Under conditions of environmental stress, RSA suppression (reflective of PNS withdrawal) allows for sympathetic activation and produces increased heart rate, which facilitates adaptive responding to environmental demands (Porges 2001). Short-term RSA decreases are commonly observed in response to psychological stressors and negative emotional states (Berntson, Cacioppo, Quigley, & Fabro, 1994; Beauchaine, 2001). Within normative adult populations, RSA suppression in response to environmental stressors has been associated with multiple adaptive outcomes, including positive social and relational functioning and successful emotion regulation (Graziano & Derefinko, 2013; Connell, Dawson, Danzo, & McKillop, 2017). In contrast, RSA dysregulation has been implicated in mood disorders (Kemp & Quintana, 2013), aggression (Mezzacappa, Tremblay, Kindlon et al., 1997), and delinquency (Kibler, Prosser, & Ma, 2004).

Given the role of RSA reactivity in associations with behavior, parenting researchers have been increasingly interested in understanding how parental RSA regulation in the face of challenging childrearing situations may be associated with caregiving. A relatively consistent finding is that RSA suppression (vagal withdrawal) is associated with sensitive parenting behaviors. For example, research with parents of infants has shown that, during the reunion phase of the Still-Face Paradigm, higher RSA suppression is associated with lower levels of negative intrusiveness (Mills-Koonce et al., 2009) and higher levels of parental sensitivity (Moore et al., 2009). Research has also indicated that highly sensitive mothers display greater RSA withdrawal compared with less sensitive mothers in reaction to hearing infant cries (Joosen et al., 2003).

Recent work has extended this line of inquiry to examine RSA regulation in parents during demanding parenting contexts such as parental discipline and conflict discussions. For example, Lorber and O'leary (2005) recorded mothers' RSA during a challenging discipline task and found that difficulties in RSA suppression were associated with overreactive and hostile discipline behaviors with their toddlers. Discipline represents a particularly challenging domain of caregiving because parents frequently need to overcome negative mood states to regulate their behavior toward their child. This may become even more important during early adolescence because the frequency and intensity of conflict interactions increase (e.g., Allison & Schultz, 2004; Laursen, Coy, & Collins, 1998). To date, few studies examine these associations in adolescence; however, Connell et al. (2017) found that higher RSA suppression during a mood induction was related to less parental anger during a subsequent parent-adolescent conflict discussion. In contrast, reduced suppression to conflict discussions between parent and adolescents has also been linked with emotionally unavailable caregiving within the same discussion task (Zhang, et al., 2017). These findings are consistent with previous research suggesting that difficulties in autonomic regulation in response to a stressor may undermine individual's ability to facilitate appropriate emotion regulation (Beauchaine, 2001; Porges, 2001). To examine this, we tested whether parental difficulties in RSA suppression during a parent-adolescent conflict task were associated with greater use of hostile and insensitive conflict behaviors over time. To our knowledge, no study has charted these associations longitudinally.

Moderating role of set-shifting capacity

Recent neurobiological conceptualizations of self-regulation have proposed that neurological processes serve an important regulatory role in controlling the influence of physiological stress response system processes on behavior (Barrett & Fleming, 2011; Thayer & Lane, 2000). Consistent with this, previous research has documented the moderating role of executive functions in process models of parenting (e.g., Deater-Deckard, Wang, Chen, & Bell, 2012; Sturge-Apple, Suor, & Skibo, 2014). Deater-Deckard et al. (2010) demonstrated that poorer working memory capacity was associated with mothers' negativity toward their children, including expressions of anger, frustration, and annoyance during challenging parent-child interactions. Although previous work in this domain has primarily focused on executive functions broadly or working memory capacity specifically, in the current study, we were interested in examining set shifting as a potential moderator of associations between physiological reactivity and parent-adolescent conflict.

In particular, set shifting is proposed as the ability to move back and forth between multiple tasks, operations, or mental sets and stability (Monsell, 2003). As such, set shifting supports the ability of individuals to take multiple perspectives and consider alternative approaches, actions, or directions while actively maintaining the task goal (Diamond, 2013; Goschke, 2000). Translated to parenting, this component of the executive suite may serve to reduce rigid response contingencies and allow for greater plasticity in caregiving in the service of socialization goals. This may be especially important for discipline contexts during adolescence, given the high degree of emotional arousal and conflict between parent and adolescent goals. To date, however, no studies have tested how set shifting may operate to regulate parental physiological reactivity within discipline contexts in adolescence. To address this gap, we examined whether set-shifting capacity functions in a moderating role in the association between parental RSA reactivity and harsh parenting. Given changes in parent-child relationship dynamics, particularly around issues of control and parental authority, it is highly likely that parental set-shifting capacity will be particularly relevant for parental regulation during this developmental period. Parents with high set-shifting capacity may be more successful in overriding physiological dysregulation during parent-adolescent conflict to enact less harsh caregiving. Conversely, for individuals who possess lower set-shifting capacity, physiological reactions may assume primacy in the dictation of behavioral responses.

Mediated moderation: The role of child attributions

Finally, family process models emphasize the importance of identifying the mechanisms underlying parental susceptibilities to

relationship contexts within the family (e.g., Belsky, 1984; Sturge-Apple, Cicchetti, Davies, & Suor, 2012). A final goal of the present study was to examine whether the moderating role of parental set-shifting capacity in associations between physiological regulation to conflict and hostile parent-adolescent conflict behavior could be explained by parental attributions regarding child behavior. Attributions reflect the manner in which parents cognitively interpret the causes of their child's misbehavior (e.g., Slep & O'Leary, 1998; Snarr, Slep, & Grande, 2009). Social cognition models of parenting have underscored how parental attributions may operate as explanatory mechanisms underlying problematic caregiver behaviors (Bugental & Johnston, 2000; Stern & Azar, 1998). In particular, parental attributions characterized by the belief that the child's misbehavior is intentional and under a high level of control have been referred to as "dysfunctional child-oriented attributions" and are associated with greater use of punitive and overreactive parenting behaviors (Dix, Ruble, Grusec, & Nixon, 1986; Leung & Slep, 2006; Smith & O'Leary, 1995; Strassberg & Treboux, 2000).

Although attributions are conceptualized as stable cognitive processes, previous research has also demonstrated the malleability of parental attributions and the potential effect on parenting (e.g., Martin, Sturge-Apple, Davies, & Romero, 2017; Slade, Belsky, Aber, & Phelps, 1999). Using a research design in which maternal child-centered responsibility attributions were experimentally manipulated, Slep & O'Leary (1998) found that mothers who were told that their child would willfully and purposefully misbehave displayed harsher and overreactive discipline as well as greater anger compared with control mothers. Furthermore, maternal attributions have been demonstrated to operate as an underlying mechanism in pathways between difficulties in regulating physiological reactivity during parent-child stressor paradigms and maternal sensitivity (e.g., Leerkes, Su, Calkins, Supple, & O'Brien, 2016). Moreover, research has suggested that the association between parental attributions and harsh caregiving may be dependent upon key individual difference variables (e.g., Wang, Deater-Deckard, & Bell, 2016), including executive functions. For example, Sturge-Apple, Suor, & Skibo (2014) found that mothers with higher working memory capacity were better able to gate off the associations between dysfunctional child-oriented attributions and harsh caregiving behaviors during discipline tasks compared with mothers with poorer working memory skills who were more susceptible to the influence of negative child attributions with respect to parenting. Parental set-shifting capacity may therefore gate off the effect of parental physiological reactivity in the activation of dysfunctional attributional biases associated with child behavior and in turn reduce the potential for hostile conflict behavior with their adolescents.

Although the potent role of dysfunctional child-oriented attributions on parenting is well documented in the literature, limited work has considered parental social cognition within process models of parental self-regulation. Furthermore, much of the literature testing associations between attributions and parenting has focused on preschool and elementary school-aged children. Less is known about the role that parental attributions may play in parenting during adolescence. This gap in knowledge is noteworthy given that increases in autonomy, reasoning skills, and impulsive behavior during adolescence (Allen & Sheeber, 2008) may result in parent's perceptions of adolescents having greater responsibility for and control of their behaviors; as such, attributional associations may be particularly strong. Sheeber et al. (2009) found, for example, that negative parental attributions for adolescent behavior during a parent-adolescent problem-solving discussion were associated with harsher parenting as observed during these same parent-adolescent discussions. Thus, parental dysfunctional child-oriented attributions may operate as a key mechanism underlying the moderating role of set-shifting capacity in the association between parental physiological dysregulation and hostile discipline practices during early adolescence.

In summary, the present study examines a set of key questions that integrate neurobiological and neuropsychological models using a multi-informant, multimethod, and multilevel approach within a longitudinal design. Based upon previous empirical findings, we hypothesized that parental difficulties in vagal regulation during conflict would be associated with use of more hostile and insensitive conflict behaviors over time. Furthermore, we hypothesized that parental set-shifting capacity would moderate these associations such that parental vagal dysregulation and difficulties with discipline would be more pronounced for those parents with lower set-shifting capacity. Finally, we hypothesized that dysfunctional child-oriented attributions would mediate this moderating effect. Over the past decade, there has been a growing body of research demonstrating the role of self-regulation within mothers, particularly within infancy and early childhood periods. Our ability to simultaneously examine these processes in mothers and fathers may yield new insights into the physiological and cognitive control capacities for parenting within discipline contexts during early adolescence. Given the dearth of research testing whether these same associations hold similarly for mothers and fathers, we made no a priori predictions regarding the role of parent gender.

Methods

Participants

Participants for this study included 193 families recruited from a city in a Northeastern area of the United States. Interested families were included in the project if they met five criteria: (i) they had an adolescent between the ages of 12 and 14; (ii) the target adolescent and two parental figures had been living together for at least the previous 3 years; (iii) at least one parental figure was the biological parent of the target teen; (iv) all participants were fluent in English; and (v) the target adolescent had no significant cognitive impairments. The majority of parents were married or engaged (87%); another 12% reported being in a committed, long-term relationship. Adolescents lived with their biological mother in the vast majority of cases (94%). Girls comprised 50% ($n = 97$) of the sample and adolescents averaged 12.4 years of age at Time 1. The median household income for this sample ranged from $55,000 to $74,999, with 14% of the sample reporting a household income less than $23,000. Median parental education was an Associate's degree (i.e., completed 2 years of college), with most parents (85%) attending at least some college. A smaller subset of the adults in this sample (12%) earned a high school diploma or GED as their highest degree. The sample largely identified themselves as White (74%), followed by Black (13.5%) and mixed race (10%), and some identified as being of Hispanic or Latino ethnicity (12%).

Procedures

At each of the two waves of data collection, mothers, fathers, and their adolescent visited the laboratory for a single, 3-hour visit. The laboratory included one room designed to resemble a living

room and equipped with audiovisual equipment to record family interactions; other comfortable rooms allowed participants to complete confidential interviews, computerized assessments, and survey measures. This study was approved by the institutional review board. Families received monetary compensation for their participation.

During the first measurement occasion, families participated in a conflict discussion task (e.g., Saxbe, Margolin, Spies Shapiro, & Baucom, 2012). Before the task, each family member chose a topic they believed was a common source of disagreement. They were then brought together and given 7 minutes to (i) choose one topic to discuss and (ii) attempt to reach a solution. The most common topics chosen were chores (36%), followed by use of electronics (e.g., TV, computer, videogames, phone) (13%), fighting with siblings (10%), and schoolwork (10%). Families were instructed to discuss the topic as they would at home, working toward a resolution. When asked to compare the discussion with those in the home, 48% of the parents reported that the nature of the laboratory discussion was about the same as ones they normally have at home, with smaller percentages indicating it was slightly more positive or negative when compared to home. Parent electrocardiogram (ECG) was recorded during the task using BioGraph Infiniti software with a precordial, two-pole ECG lead. Data from these leads were transmitted to a portable unit and were stored on a secure digital (SD) card in that unit. The ECG signal was sampled at 300 Hz and had a voltage range of −2.5 to 2.5 V. After each participant visit, ECG data were extracted from the SD card and processed offline.

Measures

Parent hostile conflict behaviors

Adolescents completed the Conflict Behavior Questionnaire (CBQ; Prinz, Foster, Kent, & O'Leary, 1979) at Waves 1 and 2. The CBQ contains 20 items answered using a true-false response format that ask about the nature of conflicts that the adolescent has with his or her parent (e.g., "My father is bossy when we talk," "my mother puts me down"). The CBQ has demonstrated high internal consistency, reliability, and good predictive validity (Foster & Robin, 1988; Prinz et al., 1979). Items were composited to create the scale. Internal consistency was high ranging, from .87 to .91 across adolescent reports on mothers and fathers across both waves.

Dysfunctional child-oriented attributions

At Wave 2, parents completed the Parent Cognition Scale (Snarr, Slep, & Grande, 2009), a 30-item measure designed to assess the degree to which parents endorse dysfunctional child-centered responsibility attributions for child misbehavior. Parents were asked to think about their target adolescent's behavior over the past 2 months and to rate various causes for misbehavior on a 6-point Likert-type scale ranging from 1 (always true) to 6 (never true). Ten items attribute child misbehavior to factors under the adolescent's control, such as adolescent willful intent to misbehave and/or adolescent desire to have a negative effect on the parent (e.g., "My child tries to push my buttons"). Internal consistency was high for mothers ($\alpha = .91$) and fathers ($\alpha = .89$). Items were recoded such that higher scores indicate higher levels of dysfunctional child-responsible attributions of children misbehavior.

Set-shifting capacity

At Wave 1, parents were administered the Trail Making Task according to the guidelines presented by Strauss et al. (2006). The test consists of two parts, both of which consist of 25 circles distributed on a sheet of paper. In part A, the circles are numbered from 1 to 25 and subjects are required to connect the consecutively numbered circles. In part B, 13 of the circles are numbered from 1 through 13; 12 of the circles are labeled with letters A–L. Subjects are required to connect the numbers from 1 through 13 and the letters A–L while alternating between the two sequences (Giovagnoli, Del Pesce, Mascheroni, Simoncelli, Laicona, & Capitani, 1996). As such, part B assesses cognitive shifting and flexibility and has been shown to be reflective of set-shifting capacity (Chaytor, Shmitter-Edgecomb, & Burr, 2006). Total time in seconds to complete part B was recorded representing the Trail Making Task-B direct scores. Longer times to complete the task, which are reflective in higher scores, indicate lower set-shifting capacity.

RSA reactivity. Parental RSA reactivity was indicated by heart rate variability (HRV). HRV was calculated using CardioPro Infiniti's HRV Analysis Module. Before calculating estimates of HRV, the digitalized ECG signals were examined and artifactual detections of R-wave occurrences were corrected. The square root of the mean of successive differences (RMSSD) in interbeat intervals was determined as a time domain estimate of HRV. This measure has been shown to provide a reliable estimate of cardiac vagal activity (Task Force, 1996) and is robust to respiratory influences during speech tasks (e.g., Hill, Siebenbrock, Sollers, & Thayer, 2009). For purposes of analyses, we were interested in parameterizing parental reactivity within the confines of the task itself by comparing parental HRV at the start of the discussion with the end of the task. In examining the data, it was evident that not all families had Interbeat Interval (IBI) recorded for the entire seventh minute of the task because of some experimenters ending the task early; however, 100% of the families had enough IBI data during the sixth minute to calculate HRV. To be consistent in our parameterizing of reactivity across all families, we therefore used the first and sixth minutes of the task reflecting change during the task. The mean RMSSD score at baseline was 44.37 (standard deviation [*SD*] = 27.03) for mothers and 40.88 (*SD* = 28.05) for fathers. The mean RMSSD score during the sixth minute was 39.97 (*SD* = 25.70) for mothers and 38.40 (*SD* = 29.19) for fathers. To parameterize HRV reactivity for analyses, we used a residualized change score in which RMSSD in the final minute of the task was regressed on RMSSD in the beginning of the task. The unstandardized predicted score, which reflects change while controlling for initial levels, were saved and used in analyses. Higher values on the residualized change score indicate less HRV suppression across the task, whereas lower values indicate greater HRV suppression across the task.

Covariates.

Observed parental conflict behavior. Observer ratings of parent behavior during the conflict task were collected using the Problem Discussion Coding System (Sturge-Apple & Martin, 2016), a continuous rating system designed to capture parental behavior during a problem discussion task. The Problem Discussion Coding System required trained observers to watch the entire parent-adolescent interaction and provide a continuous rating from 1 (*not at all characteristic*) to 9 (*highly characteristic*) based on the frequency, pattern, and intensity of each dimension

of parent behavior. Hostility referred to parent's use of harsh, angry, critical, and/or rejecting behavior toward the adolescent. Humor/laugh reflected displays of humor and statements primarily lighthearted in tone including laughing or smiling in an amused, pleasant manner, and attempts at good-natured humor. Two teams consisting of two independent coders were responsible for coding mothers and fathers separately. Within a team, coders overlapped on 20% of the interactions; resulting intraclass correlation coefficients ranged from .73 to .80 across the four codes.

Marital satisfaction. Each partner's relationship satisfaction was assessed with the four-item Couples Satisfaction Index (Funk & Rogge, 2007), which provides global evaluations of romantic relationships (e.g., "I have a warm and comfortable relationship with my partner," "How rewarding is your relationship with your partner?"). This measure has been extensively used and has demonstrated strong validity and reliability across diverse partnerships (e.g., Peltz, Rogge, & Sturge-Apple, 2018; Rogge, Fincham, Crasta, & Maniaci, 2017). Items were rated on 6- and 7-point response scales and summed so that higher scores indicated higher levels of satisfaction and demonstrated high internal consistency in the current sample ($\alpha_{males} = .93$, $\alpha_{females} = .94$).

Results

Missing data in this study came from two sources. First, 16 families (8% of the sample) did not participate in the second wave of data collection. A comparison of these families with those who returned for the second wave evidenced no differences on any of the variables collected at Wave 1. Second, 15 mothers and 6 fathers did not have valid ECG assessments because of a computer malfunction. In addition, two mothers and two fathers had RMSSD values that were greater than 3 *SD* from the mean and were removed. These values were treated as missing data. We performed Little's missing completely at random test for all variables included in the analyses. This test suggested that the data were missing completely at random: χ^2 (39) = 49.284, $p = .13$.

Table 1 shows the *M*, *SD*, and correlations for the main variables in the study. We examined whether mean differences in primary study variables were present across parent gender. Results of one-way analysis of variance comparing mothers and fathers indicated no significant mean differences on constructs with the exception of set-shifting capacity, with mothers exhibiting greater set-shifting compared with fathers: F (1, 382) = 11.60, $p < .01$.

Primary analyses

To test our mediated moderation model, a series of path models were specified using Amos 24 with full information maximum likelihood to retain the full sample (Enders & Bandalos, 2001). Before running analyses, parent HRV reactivity and set-shifting capacity were standardized to avoid problems with multicollinearity (Aiken & West, 1991). Models were run in a stepwise fashion to examine the influence of main effects on parental harsh conflict behavior at Wave 2 with an autoregressive effect controlling for Wave 1 harsh conflict. In all models, child gender, parent hostility, and humor/laugh during the conflict discussion; parent marital relationship satisfaction; and parent baseline HRV were included as exogenous covariates of the model. To examine the potential influence of partner HRV reactivity, we ran models specifying partner HRV reactivity as a covariate; however, primary findings were not affected by the inclusion of the partner's reactivity and it was removed from the final model analyses.

Our first model examined the main effects of parental HRV reactivity and set-shifting capacity on harsh conflict behavior. The next model included the interaction effect of HRV reactivity and set-shifting capacity. Significant interactions were clarified through post hoc statistical tests (e.g., simple slope analyses) to examine whether the regression slopes representing associations between parental HRV reactivity and parenting were significantly different from zero for different levels of set-shifting capacity (Preacher, Curran, & Bauer, 2006). Upon establishing significant moderating effects, we next tested whether parental dysfunctional child-oriented attributions mediated the moderated pathways. This represents a first stage mediated moderation model (e.g., Edwards & Lambert, 2007). Within this framework, mediated moderation is supported when the moderator similarly influences the pathway between parental HRV reactivity and the mediating variable; in turn, the mediating variable is associated with the parenting outcome variables.

We first examined a model in which HRV reactivity and set-shifting capacity were specified as potential predictors of change in parental hostile conflict behavior. In addition, covariances were specified among all exogenous predictors. The model was fully saturated with zero degrees of freedom and therefore had perfect model fit (i.e., χ^2 (0) = 0, comparative fit index = 1.00, Tucker–Lewis index = 1.00, root mean square error of approximation = 0.00). Turning to the pathway estimates, fathers with dampened HRV suppression (i.e., higher residual HRV reactivity score), reflecting poorer cardiac regulation, demonstrated increases in hostile conflict behavior over time ($\beta = .16$, $p < .02$). For mothers, dampened HRV suppression also significantly associated with greater increases in their hostile conflict behaviors over time ($\beta = .16$, $p < .05$). Comparisons between mothers' and fathers' HRV reactivity using the critical ratio of difference test indicated no significant difference in model pathways by parent gender (completely randomized design = 0.41, $p > .05$). This suggests that both mothers' and fathers' conflict behaviors may be similarly affected by their physiological dysregulation during interactions with their adolescent. Results also suggest that set-shifting capacity did not directly impact change in parental conflict behavior over time for both mothers ($\beta = -.02$, $p = .79$) and fathers ($\beta = .09$, $p = .15$).

Given the direct effects of parental HRV reactivity on conflict behaviors, we next evaluated whether parents' set-shifting capacity moderated this association. An interaction between HRV reactivity and set-shifting capacity was included in the model as a predictor. With covariances specified among all exogenous predictors, the model was again fully identified. Results indicated that the interaction between HRV reactivity and set-shifting capacity was significant for fathers, but not mother's hostile conflict behavior over time (Table 2). A comparison of these pathways across mothers and fathers using the critical ratio of difference test indicated a significant difference in this pathway by parent gender (completely randomized design = 3.85, $p < .05$), suggesting that the pathway was significantly stronger for fathers compared with mothers. To illuminate the nature of this interaction, simple slope analyses for fathers were conducted with low and high set-shifting capacity operationalized as 1 *SD* from the mean, respectively. Given that higher completion time on the set-shifting measure indicates poorer set-shifting capacity, these were graphed at +1 *SD* from the mean. Conversely, shorter completion times on the set-shifting measure indicated higher set-shifting capacity

Table 1. M, SD, and the bivariate correlations for the primary variables

	Mother										
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Child gender	–										
2. W1 HRV reactivity	.07	–									
3. W1 Set-shifting difficulty	.03	.15*	–								
4. W1 HRV × set-shifting interaction	.01	.21***	.47***	–							
5. W2 Dysfunctional attributions	−.10	−.05	.03	−.002	–						
6. W1 Parental hostile conflict behavior	−.11	.05	.17**	.16**	.16**	–					
7. W2 Parental hostile conflict behavior	.02	.16**	.08	.01	.34***	.36***	–				
8. W1 Obs parent hostility	−.05	.17**	.19***	.10	.22***	.09	.004	–			
9. W1 Obs parent humor/laugh	−.03	−.10	−.17**	−.01	−.25***	−.11	−.12	−.19***	–		
10. W1 Marital relationship satisfaction	.12	.10	−.04	.03	−.18**	−.15*	−.13	−.09	.10	–	
11. W1 Epoch 1 HRV	.01	−.13*	.14*	.10	−.21***	.11	.07	−.02	.09	.01	–
M	–	−0.03	0.00	0.15	2.72	2.44	2.42	1.72	2.49	32.53	44.37
SD	–	1.02	1.00	1.08	0.94	3.27	3.43	1.38	1.64	10.50	27.03
	Father										
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Child gender	–										
2. W1 HRV reactivity	.02	–									
3. W1 Set-shifting difficulty	−.12	.05	–								
4. W1 HRV × set-shifting interaction	.02	.01	.01	–							
5. W2 Dysfunctional attributions	−.08	.11	.04	.17**	–						
6. W1 Parental hostile conflict behavior	−.16**	.04	.26***	.06	.21**	–					
7. W2 Parental hostile conflict behavior	−.15*	.17**	.25***	.28***	.39***	.57***	–				
8. W1 Obs parent hostility	.03	.10	−.02	−.01	.09	.06	.06	–			
9. W1 Obs parent humor/laugh	.04	−.02	−.09	.04	−.06	−.14*	−.14*	−.05	–		
10. W1 Marital relationship satisfaction	.06	.03	.03	.09	−.10	−.10	−.02	−.03	.09	–	
11. W1 Epoch 1 HRV	.06	.13	−.03	−.004	.06	−.15**	.03	−.03	−.06	−.06	–
M	–	0.03	0.00	0.05	2.70	2.72	3.01	1.87	1.97	33.18	40.88
SD	–	0.98	1.00	0.96	0.88	3.75	4.42	1.59	1.20	9.69	28.06

Note. HRV = heart rate variability; *M* = mean; Obs = observed; *SD* = standard deviation; W = Wave. *$p < .10$, **$p < .05$, ***$p < .001$.

and were graphed at −1 *SD* from the mean. A graph of this interaction is presented in Figure 2. Post hoc simple slope analyses for fathers revealed that the simple slope for poorer set-shifting capacity (+1 *SD*) was significantly different from zero ($B = 1.71$, $p \leq .001$) and indicated that for fathers with poorer shifting capacity, increased difficulties in HRV regulation were associated with elevated hostile conflict behavior over time. In contrast, the slope for greater set-shifting capacity (−1 *SD*) was not significantly different from zero ($B = -0.46$, $p = .23$), suggesting that for fathers with higher set-shifting capacity, physiological reactivity was not associated with hostile conflict behavior over time.

Our final set of analyses followed up the significant interaction effect for fathers by testing the presence of mediated moderation through paternal dysfunctional child-oriented attributions (Table 3). We specified a model in which fathers' dysfunctional child-oriented attributions and hostile conflict behavior at Wave 2 were regressed onto predictor variables. Model fit was poor: χ^2 (2) = 35.75, $p = .00$, comparative fit index = 0.86, Tucker–Lewis index = −8.48, root mean square error of approximation = 0.21. Upon inspection, it was determined that poor fit was a function of the lack of a specification of the association between Wave 1 parental hostile conflict behavior and Wave 2 dysfunctional

Table 2. Pathway coefficient estimates testing interactive effects of HRV reactivity and set-shifting capacity on parent hostile conflict behavior with covariates and autoregressive effects (N = 193)

	Estimate *(B)*	*SE*	*β*	*p*
Dependent variable: W2 mother hostile conflict behavior				
Predictors				
Child gender	0.26	0.48	0.04	.58
W1 Mother HRV reactivity	0.61	0.25	0.18	.02**
W1 Mother set-shifting difficulty	0.15	0.28	0.04	.59
W1 Mother HRV × set-shifting	−0.37	0.26	−0.12	.16
W1 Mother hostility	−0.25	0.18	−0.10	.16
W1 Mother humor/laugh	−0.13	0.15	−0.06	.39
W1 Marital relationship satisfaction	−0.02	0.03	−0.07	.34
W1 Mother baseline HRV	0.01	0.01	0.04	.56
W1 Mother hostile conflict behavior	0.40	0.08	0.38	<.001**
Dependent variable: W2 father hostile conflict behavior				
Predictors				
Child gender	−0.41	0.52	−0.05	.43
W1 Father HRV reactivity	0.62	0.27	0.14	.02**
W1 Father set-shifting difficulty	0.44	0.26	0.10	.10
W1 Father HRV × set-shifting	1.09	0.27	0.24	<.001**
W1 Father hostility	0.10	0.16	0.04	.54
W1 Father humor/laugh	−0.19	0.22	−0.05	.37
W1 Marital relationship satisfaction	0.004	0.03	0.01	.89
W1 Father baseline HRV	0.01	0.01	0.09	.16
W1 Father hostile conflict behavior	0.59	0.07	0.51	<.001**

Note. HRV reactivity indicates higher residual HRV reactivity score reflects dampened HRV suppression and thus poorer cardiac regulation. HRV = heart rate variability; *SE*, standard error; W, Wave.

child-responsible attributions. To address this, we specified a covariance between these two constructs, resulting in a fully identified model and by extension acceptable model fit. Importantly, primary findings in the study were consistent whether this path was included or not. Analyses revealed that the interaction between fathers' HRV reactivity and set-shifting capacity was significantly associated with dysfunctional child-oriented attributions. In turn, fathers' dysfunctional child-oriented attributions were associated with increased hostile conflict behavior over time. Post hoc simple slope analyses were again conducted (Figure 3). Results indicated that for fathers with poorer set-shifting capacity (i.e., +1 *SD* of the time needed for completing trail-making task), dampened HRV suppression (i.e., increased difficulty in HRV regulation) significantly predicted fathers' dysfunctional child-oriented attributions at Wave 2 ($B = 0.24$, $p = .02$). The same associations were not significant for fathers with greater set-shifting capacity ($B = -0.01$, $p = .51$).

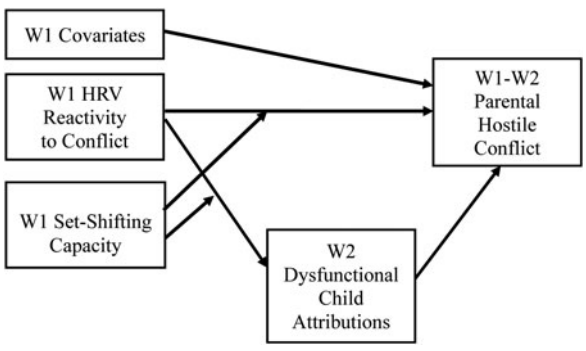

Figure 1. Conceptual model outlining pathways examined in testing process pathways. W = Wave.

To test for mediated moderation, a bootstrapping test was performed with PRODCLIN software (MacKinnon, Fritz, Williams, & Lockwood, 2007) on the indirect pathway involving dysfunctional child-oriented attributions. The indirect pathway achieved significance, such that the combination of dampened HRV suppression and poorer set-shifting capacity predicted more dysfunctional child-responsible attributions and, thereby, increases in hostile conflict behavior by fathers between the two waves (estimate = 0.18; bootstrapped 95% confidence interval: 0.02, 0.38).

Discussion

Self-regulation models of parenting stress the primacy of regulatory processes in shaping caregiving. Within these frameworks, a main assumption is that physiological and cognitive functioning operate to either support or undermine parent's ability to care for their children (e.g., Paulson & Sputa, 1996). Toward adopting a

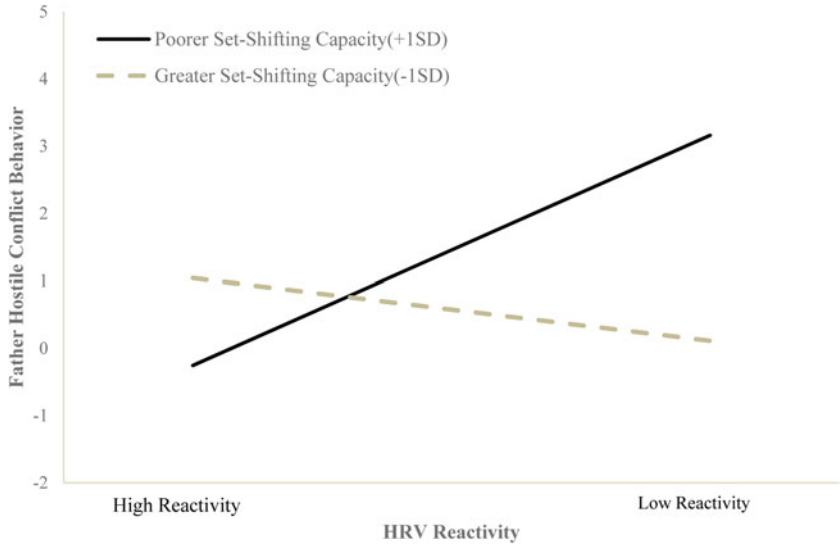

Figure 2. HRV reactivity × set-shifting capacity interaction on changes of father hostile conflict behavior. *Note*. Dashed line represents nonsignificant slope. High and low HRV reactivity were calculated at ±1 *SD* from the mean. Low HRV reactivity referred to dampened HRV suppression during parent-adolescent conflict discussion. HRV = heart rate variability; *SD* = standard deviation.

process-oriented approach to family research, the present study represents the first attempt to examine both physiological and cognitive processes with respect to parenting over time in mothers and fathers during adolescence. Our findings suggest that parental physiological regulation and cognitive control capacities serve important functions in reducing hostile parent conflict behaviors. In addition, our findings point to the importance of examining these processes in both mothers and fathers, as physiological and cognitive regulation may operate differently depending upon parent gender in process models of parenting. Finally, we identify how parental social cognitions about their adolescent may operate as a potential explanatory construct in process models of self-regulation.

In our first analysis, findings determined that parents' difficulties in HRV suppression in the context of parent-adolescent conflict discussions were associated with increases over the course of 1 year in hostile and insensitive conflict behavior with their adolescent. This finding is consistent with models of HRV reactivity and emotion regulation, which suggest that short-term withdrawal of cardiac vagal control is an adaptive response of the stress response system that allows for greater ability to contend with external stressors. As such, reduced vagal suppression in

Table 3. Pathway coefficient estimates testing the mediating effect of dysfunctional child-oriented attributions on hostile conflict behavior for fathers (N = 193)

	Estimate *(B)*	*SE*	*β*	*p*
Child gender → W2 father hostile conflict behavior	−0.32	0.50	−0.04	.52
Child gender → W2 father child-oriented attributions	−0.1	0.13	−0.07	.37
W1 Father HRV reactivity→ W2 father hostile conflict behavior	0.53	0.26	0.12	.04**
W1 Father HRV reactivity→ W2 father child-oriented attributions	0.09	0.07	0.10	.21
W1 Father set-shifting difficulty → W2 father hostile conflict behavior	0.45	0.25	0.10	.08
W1 Father set-shifting difficulty → W2 father child-oriented attributions	0.02	0.07	0.02	.75
W1 Father HRV × set-shifting → W2 father hostile conflict behavior	0.92	0.26	0.20	<.001**
W1 Father HRV × set-shifting → W2 father child-oriented attributions	0.15	0.07	0.17	.03**
W1 Father hostility→ W2 father hostile conflict behavior	0.05	0.16	0.02	.74
W1 Father hostility→ W2 father child-oriented attributions	0.05	0.04	0.08	.27
W1 Father humor/laugh→ W2 father hostile conflict behavior	−0.18	0.21	−0.05	.38
W1 Father humor/laugh→ W2 father child-oriented attributions	−0.02	0.06	−0.03	.71
W1Marital relationship satisfaction→ W2 father hostile conflict behavior	0.01	0.03	0.03	.62
W1Marital relationship satisfaction→ W2 father child-oriented attributions	−0.01	0.01	−0.10	.18
W1 Father baseline HRV→ W2 father hostile conflict behavior	0.01	0.01	0.07	.23
W1 Father baseline HRV→ W2 father child-oriented attributions	0.001	0.002	0.04	.59
W2 Father child-oriented attributions → W2 father hostile conflict behavior	1.14	0.30	0.23	<.001**
W1 → W2 father hostile conflict behavior	0.55	0.07	0.48	<.001**

HRV = heart rate variability; *SE*, standard error; W, Wave.

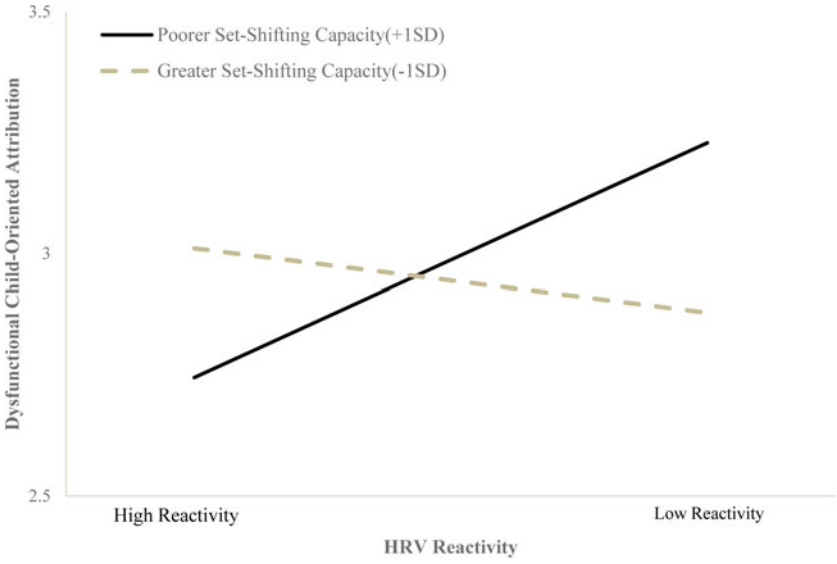

Figure 3. HRV reactivity × set-shifting capacity interaction on Wave 2 dysfunctional child-oriented attributions for fathers. *Note*. Dashed line represents nonsignificant slope. High and low HRV reactivity were calculated at ±1 *SD* from the mean. Low HRV reactivity referred to dampened HRV suppression during parent-adolescent conflict discussion. HRV = heart rate variability; *SD* = standard deviation.

parent-adolescent contexts may indicate difficulties in activating coping mechanisms in the face of conflictual interactions, resulting in greater use of harsh caregiving over time. RSA dysregulation has been implicated in problematic caregiving behaviors. For example, parents at elevated risk for child maltreatment demonstrate dampened RSA suppression to challenge tasks compared with low-risk parents, suggesting that high-risk parents may have reduced RSA suppression and conversely less physiological flexibility in response to environmental demands (Crouch et al., 2015). In addition, model testing results suggest that for both mothers and fathers, difficulties in physiological regulation during parent-adolescent conflict interactions may undermine caregiving over time, a finding that has been previously undocumented in the literature. Taken together, the present study points to the potential importance of ANS functioning within the stress response system as a determinant of caregiving behaviors during adolescence. Our findings corroborate earlier work within the broader literature, which has demonstrated that maternal difficulties in ANS regulation during challenging childrearing interactions in early childhood is associated with decreased sensitivity as well as increased harsh caregiving behaviors (Sturge-Apple, Skibo, Rogosch, Ignjatovic, & Heinzelman, 2011). The current study extends this research to adolescence, however, suggesting that the regulatory function of physiological systems may operate across developmental periods, with important implications for parenting during the transition across adolescence. It will be important for future research to test whether these processes are germane to the ANS branch of the stress response system or may be more broadly represented in other domains such as neuroendocrine functioning.

Second, we found evidence that set-shifting capacity may operate as a potential individual difference variable with respect to the association between RSA reactivity and fathers increased hostile conflict behavior. This moderating role of set-shifting capacity on physiological functioning is consistent with conceptual frameworks that propose the integration of cognitive and physiological systems within the brain and serve in the control of emotion and social behavior (e.g., Thayer & Lane, 2000). In particular, regions within the prefrontal cortex support aspects of executive functions including shifting attention, consideration of alternative responses and goals, and effortful control. In turn, these cognitive processes are proposed to operate in a top-down manner with respect to physiological reactivity to environmental challenge. In support of this, studies on humans and animals have demonstrated that activity within the prefrontal cortex modulates cardiovascular activity, including HRV (Verberne & Owens, 1998), suggesting the integration of neurological processes. Our findings build upon previous research documenting interactive effects of global executive functioning and physiological reactivity in the etiology of harsh parenting (e.g., Deater-Deckard & Bell, 2017).

Although rarely studied in research on parenting, greater set-shifting capacity has been implicated in supporting effective emotion regulation (McRae, Jacobs, Ray, John, & Gross, 2012). Given the emotionally charged context of parent-adolescent conflict, parental set shifting may be uniquely important in modulating parental arousal states in the face of a challenging adolescent. In the present study, higher set-shifting capacity was effective in gating off the impact of difficulties in HRV regulation on change in hostile conflict behaviors over time. The locus of the moderating effect was associated with reduced set-shifting capacity, however, such that as difficulties in HRV regulation increased, these parents exhibited greater hostile conflict over time. During conflictual discussions during adolescence, reduced set-shifting capacity may inhibit the ability of parents to disengage from rigid goal pursuit and consider alternative means and objectives with respect to resolving conflicts with their adolescent. As such, lower capacities within this domain of cognitive control may not be effective in regulating parental difficulties in physiological activation, resulting in greater use of hostile and harsh caregiving responses. Considered within a developmental perspective, fathers with poorer set-shifting capacity may experience greater difficulties in adapting to the changing nature of parental control during the transition through adolescence.

In an attempt to elucidate an underlying process that may serve to explain the moderating role of set-shifting capacity, we further examined dysfunctional child-oriented attributions as a mediating mechanism. Results supported the role that fathers' dysfunctional child-oriented attributions regarding the locus of adolescent behavior may play an explanatory role in this

moderating effect. Parental attributions reflect a social cognitive component of parenting and have been demonstrated to be important predictors of caregiving behaviors (e.g., Bugental & Johnston, 2000), and, in particular, harsh and insensitive parenting (Leung & Slep, 2006). Self-regulation frameworks suggest that physiological arousal in challenging contexts may activate negative attributional biases as a means for processing and rationalizing negative stimuli, which eventuates in associated behavioral manifestations (e.g., Brown & Rogers, 1991; Lemerise & Arsenio, 2000). In support of this, parental difficulties in physiological regulation have been associated with attributional processes related to child behavior. For example, in a recent study, Leerkes et al. (2016) found that mothers' physiological arousal during stressful interactions with her infant were associated with her attributions around infant distress and subsequent maternal sensitivity. The pathway between a father's HRV regulation and increased harsh discipline was still significant with the mediational pathway in the model, indicating that attributions did not fully explain this direct effect. The findings demonstrate however that parental attributions may operate as one potential mediating mechanism linking physiological reactivity to hostile and insensitive conflict behaviors over time during early adolescence. Furthermore, consistent with previous research examining the regulatory role of executive functions on attributions (Sturge-Apple et al., 2017), parental set-shifting capacities may also serve to potentiate the influence of physiological reactivity on parental dysfunctional child-oriented attributions and conversely parental caregiving around parent-adolescent conflict.

Finally, the present study revealed differences between mothers and fathers in process pathways that bear mention. Against the surfeit of studies examining self-regulation within mothers, our findings underscore the importance of research within this area of study to include fathers. Recent cultural shifts regarding father involvement and concomitant research exploring the differential effects of mothers and fathers on children's development highlight the value and effect of paternal parenting over and above maternal parenting (Cabrera, Tamis-LeMonda, Bradley, Hofferth, & Lamb, 2000; Lamb, 2010). Additionally, father's parenting has been shown to uniquely influence children's cognitive, social, and academic development (Tamis-LeMonda, Shannon, Cabrera, & Lamb, 2004). Research has also suggested that fathers and mothers may approach parenting differently during adolescence (Steinberg & Silk, 2002), but few studies include both fathers and mothers within this developmental period. With respect to the current study, process pathways regarding physiological difficulties, attributional biases, and hostile and insensitive parenting appeared to be more robust for fathers compared with mothers. This is consistent with the father vulnerability hypothesis that suggests that fathers' caregiving may be more susceptible to contextual and relational factors than that of mothers (Cummings, Merrilees, & Ward-George, 2010) by virtue of their parental role being less scripted and socially defined. Research has born this hypothesis out in adolescence with respect to family dynamics (Stevenson, Fabricius, et al., 2014); however, given this is one of the first studies to examine self-regulation capacity within fathers, our findings require replication in future work.

We did not find evidence of associations between mother's cognitive control capacities and model pathways. This stands in contrast to the body of work demonstrating effects of maternal executive functions in the etiology of caregiving behaviors, primarily in mothers of infants and young children. It is possible that the lack of findings for mothers in the present study reflects that different executive functioning domains may operate differently for mothers in the context of parenting. For example, Shaffer and Obradovic (2017) found differential pathways for mothers between parental inhibitory control and emotion regulation in the prediction of parenting. Moreover, Sturge-Apple et al. (2017) reported that, within mothers, inhibitory control might be more proximal in supporting sensitive caregiving within discipline contexts in comparison to working memory capacity. Different domains of cognitive control may operate differently for mothers and fathers; however, given the lack of research comparing self-regulation capacities across mothers and fathers, this is only speculative; future research is needed to bear this out.

Despite the potential utility of the present research, there are several limitations that warrant discussion. First, our sample consisted of predominantly White, middle class, two-parent families drawn from a community-based sample. As such, caution should be exercised in applying these findings to other types of families (Sturge-Apple, Davies, Cicchetti, & Fittoria, 2014). For example, there is evidence that in African American cultures, harsh discipline is much more normative, and can even serve as a protective parenting practice when children are at risk of experiencing harsher institutional and societal treatments (Deater-Deckard, Dodge, Bates, Pettit, & Gregory, 1996; Pinderhughes, Dodge, Bates, Pettit, Zelli, & Arnaldo, 2000). Future research should consider cultural and ethnic differences in these effects, as well as the meaning and intention behind parental discipline practices.

Second, our assessment of parent hostile conflict behaviors relied on a single assessment. Our use of adolescent reports on conflict behaviors helped to reduce shared method variance with our parental reports on child-oriented attributions; however, our findings would have been more robust if additional indicators or assessments were included. Third, given the constraints of assessing multiple domains of functioning within family research, set-shifting capacity was measured using a single task. Although this task has been reported as a reliable and valid assessment of set shifting, we recognize that it is important to measure executive functions using multiple assessments when possible. Fourth, although families indicated that the discussion task was largely similar to those at home, our conflict discussion may not represent actual discussions in the home. Fifth, the present study did not include a silent baseline period as the initial value for parameterizing parental HRV reactivity. Although we were interested in capturing individual functioning at the beginning of the task as well as the peak of the task, effectively demonstrating regulation during the task, the initial value is not a pure baseline assessment. It would be interesting for future research to examine the differences between the two approaches for parameterizing physiological reactivity. Finally, the present study did not control for respiration rate when calculating vagal reactivity within the task. Controlling for respiration has been a long debate; recent theorists have challenged the necessity of this practice given the constraints such controls place on participants when considered against ecological validity. In the current study, we used RMSSD to parameterize HRV because this index is relatively free of respiratory influences contrary to high-frequency parameters (e.g., Laborde, Mosley, & Thayer, 2017; Penttilä et al., 2001). In particular, empirical studies have demonstrated that respiration within speech-based tasks is not associated with RMSSD indices of HRV.

In conclusion, against a backdrop of a preponderant focus on mothers in the parental self-regulation literature, our findings suggest that research may benefit from a full delineation of the

individual factors that may mitigate or potentiate experience and outcomes for both mothers and fathers (Sturge-Apple, Cicchetti, Davies, & Suor, 2012). Our findings may have important implications for clinical interventions toward the amelioration of harsh parenting and difficulties in parent-adolescent relationships. In particular, targeting improvement in parental abilities to be more flexible with respect to socialization goals and behaviors during the changing nature of parent-adolescent relationships over the course of early adolescence in parenting prevention and intervention efforts may assist efforts in the amelioration of harsh parental attributions regarding child behavior and caregiving over time.

Moreover, the strength of the current study lies in the demonstration of the potential for set-shifting capacity to operate as a key individual difference variable in process-oriented approaches to understanding how parental physiological regulation in the context of adolescent conflict may affect caregiving over time during this critical developmental transition. Finally, progress in understanding the mechanisms through which self-regulation constructs impact parenting hinges upon identifying mediating factors. Our demonstration that parental dysfunctional child-oriented attributions may operate as one underlying pathway is an important step for this field of research.

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