Gender differences in the association between cardiovascular reactivity and aggressive conduct[☆]

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Abstract

The purpose of the present investigation was to examine the association between cardiovascular reactivity to provocation and physically and relationally aggressive conduct. Blood pressure and heart rate were assessed among seventy-seven 5th-grade participants during a period of rest and while discussing a relational provocation. In addition, teachers reported on participants' physically and relationally aggressive behavior. Results provided support for the hypothesis that heightened cardiac reactivity to provocation would be associated with relational forms of aggression among girls. In contrast, for boys, lower cardiac reactivity was associated with physical aggression. These results suggest that the association between cardiovascular reactivity and aggression differs for males and females and that reactivity following relational provocation may be an especially important predictor of relational aggression among girls. Implications for interventions among aggressive children are discussed.
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In recent years, psychologists have provided evidence indicating that measures of cardiac activity may inform our understanding of children's aggressive conduct (Hubbard et al., 2002; Lorber, 2004; Scarpa and Raine, 1997). However, a number of important limitations remain regarding this research domain. For example, there is a notable lack of attention to gender in most studies in this area; in fact, most work has failed to include girls as participants, and those that have tend to focus on forms of aggression more common among boys (i.e., physical aggression) to the exclusion of types of aggression that are more salient for girls (i.e., relational aggression). In addition, few studies examine gender differences in cardiovascular responses to relational provocation and little research investigates the association between such reactivity and aggressive behaviors. The purpose of the present investigation was to examine whether cardiovascular reactivity following relational stress was associated with physically and relationally aggressive behavior patterns and whether this relation differed for boys and girls.

Factors such as cardiovascular activity may play an important role in children's inability to inhibit aggression despite socialization away from such conduct (Raine, 2002). Researchers have provided two competing predictions regarding the association between cardiovascular reactivity to stress or provocation and aggression. On the one hand, cardiac reactivity may be associated with heightened aggression. For example, aggressive individuals may exhibit exaggerated fight/flight responses to provocation (Beauchaine et al., 2001; Rappaport and Thomas, 2004). The fight/flight system, activated when individuals perceive stimuli as threatening, involves parasympathetic withdrawal and relatively dominant sympathetic influence on cardiac activity. These changes, in turn, result in increases in blood pressure (BP; Gump et al., 1999; Harden et al., 1995) and heart rate (HR; Beauchaine et al., 2001). Such physiological changes allow increased provisions of metabolic

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resources for surviving or coping with environmental threat. The heightened cardiac activity resulting from exaggerated fight/flight responses to stress may serve as an energizer of aggressive responding to provocation (Scarpa and Raine, 1997).

In a similar vein, the excitation-transfer approach suggests that heightened cardiovascular arousal, regardless of its origin, may intensify aggressive responding following provocation (Zillman, 1971). For example, in one study, male under-graduates were provoked by a confederate and subsequently watched films meant to heighten their blood pressure and heart rate (aggressive and erotic films). Then, participants were provided with the opportunity to shock their provocateur. Watching erotic and aggressive films was associated with allocating more intense shocks to the provocateur than watching neutral films (Zillman, 1971). Interestingly, aggressive respond-ing was higher following viewing the erotic film than viewing the aggressive film, indicating that cardiovascular arousal can facilitate aggressive behavior following provocation even when it is not directly the result of provocation (Zillman, 1971). From both the fight/flight and excitation-transfer approaches, then, cardiovascular reactivity is expected to energize aggressive behavior following provocation.

However, an alternative theoretical approach suggests that cardiovascular reactivity may be *negatively* related to aggres-sive conduct. Specifically, Raine (2002) proposed that low levels of cardiovascular arousal predispose individuals to involvement in antisocial behavior because it represents an aversive physiological state. Individuals experiencing such chronic underarousal may engage in antisocial or delinquent behavior as a means of increasing their arousal to a more comfortable level. Although research assessing the relation between chronic underarousal and aggression has primarily focused on resting arousal rather than reactivity (e.g., Herpertz et al., 2003; Kindlon et al., 1995), recently researchers have used this theory to suggest that relatively low levels of cardiovascular reactivity to stress or provocation will predict aggression (e.g., Kibler et al., 2004; Schneider et al., 2002).

In the empirical literature, the majority of the BP reactivity research has provided support for the hypothesis that *heigh-tened* reactivity to provocation is associated with aggression. Studies have demonstrated that hostility (including behavioral aggression) is positively related to BP reactivity following harassment among adult men and women (Suarez et al., 1993, 1998; Suarez and Williams, 1989; although see Powch and Houston, 1996). In addition, hostility predicted increases in systolic BP and diastolic BP among African-American children (Gump et al., 1999). However, one study failed to find an association between BP reactivity and aggression in children (Schneider et al., 2002). Nevertheless, taken together, most research indicates that BP reactivity is related to heightened involvement in aggressive conduct.

In contrast, the findings regarding the association between heart rate reactivity and aggression have been mixed. Some research has provided support for the hypothesis that heart reactivity to stress is positively associated with aggressive behavior patterns (see Dodge and Pettit, 2003; Harden et al., 1995; Lorber, 2004; Waschbusch et al., 2002; Williams et al.,

2003). For example, Williams et al. (2003) reported that aggression was positively related to increases in HR among boys told that a peer with whom they were going to work on a task was in a bad mood and wanted to pick a fight with them. In another study, adolescents who exhibited high levels of HR reactivity when observing a videotape of a peer conflict were rated by teachers as exhibiting more externalizing behaviors than their peers (see Dodge and Pettit, 2003). Finally, the most comprehensive meta-analysis to date assessing the association between HR reactivity and aggression revealed that HR reactivity was positively associated with conduct problems in childhood and aggressive behavior in adults (Lorber, 2004).

However, some findings suggest that HR reactivity and aggressive behavior are not significantly related (Powch and Houston, 1996), and others have actually found a negative association between these factors (Hubbard et al., 2002; Schneider et al., 2002). In one study, HR reactivity during a game in which a confederate cheats was negatively related to teacher-reported reactive aggression (Hubbard et al., 2002). In addition, in their meta-analysis of cardiovascular correlates of misconduct (e.g., externalizing or aggressive behavior), Kibler et al. (2004) found that HR reactivity was negatively associated with behavior problems in children and adolescents. Overall, then, some research has provided support for the hypothesis that heightened HR reactivity is associated with aggression whereas other research has found that low levels of reactivity predict aggression.

Although a number of studies have assessed the relation between cardiovascular reactivity and aggression, an important limitation of the work is a lack of inclusion of girls as participants and a failure to investigate the role of gender in this relation (e.g., Suarez et al., 1993). For example, few studies have explored the association between aggression and cardio-vascular reactivity following provocations that are especially upsetting for girls. Many researchers have proposed that females are more sensitive to disruption of interpersonal relationships (e.g., Leadbeater et al., 1999; Rudolph, 2002) whereas males are more sensitive to issues of achievement, status, and control (Smith and Gallo, 1999). Indeed, girls tend to report that interpersonal stress and provocations are more stressful, hurtful, and emotionally upsetting than do boys (Crick, 1995; Crick et al., 2002; Galen and Underwood, 1997; Nelson and Crick, 1999; Rudolph, 2002). From this perspective, boys will be more reactive to *instrumental* provocation (e.g., damage to property, physical harm, or a lack of control) whereas females will be more reactive to *relational* provocation (e.g., relational slights or social exclusion; Crick, 1995; Crick et al., 2002).

Consistent with this proposal, some studies indicate that females exhibit greater cardiovascular reactivity to tasks consisting of interpersonal disagreement or rejection, whereas males display heightened cardiovascular response to tasks that threaten achievement or dominance (Chen et al., 2002; Ewart et al., 1991; Light et al., 1993; Moore and Stuart, 2004; Smith and Gallo, 1999). For example, Davis and Matthews (1996) found gender differences in response to an interpersonal stressor, with women exhibiting greater diastolic BP increases

than men during a discussion with a confederate. In the present study, reactivity to relational provocation was assessed to allow for a relatively sensitive test of the association between cardiovascular arousal and aggression for girls. It was expected that girls would exhibit greater cardiovascular reactivity to relational provocation than boys.

The lack of research including girls and relational provocations is further complicated by the fact that the vast majority of researchers focus on forms of aggression that are more salient for males than for females (Rappaport and Thomas, 2004). In effect, even when studies do include females, they tend to examine physical aggression, neglecting relational forms of these social experiences. Whereas physical aggression is defined as behaviors that harm others though damage to one's physical well-being, relational aggression includes behaviors that harm others through damage to relationships or feelings of acceptance, friendship, or group inclusion (e.g., rumor-spreading, giving another child the "silent treatment;" Crick and Grotpeter, 1995; Crick et al., 1999; Tomada and Schneider, 1997; for discussion regarding related constructs such as indirect or social aggression, see Bjorkqvist et al., 1992; Galen and Underwood, 1997).

Studies assessing relational aggression in addition to physical aggression have clarified important questions regarding gender differences in aggressive conduct. For example, inclusion of relational aggression has provided evidence that girls are not less aggressive than their male counterparts. Rather, in contrast to the gender breakdown observed with physical aggression (Parke and Slaby, 1983), most work has found that girls are more relationally aggressive than boys (Crick and Grotpeter, 1995; Crick et al., 1999; Hawley, 2003; Ostrov and Keating, 2004; Tomada and Schneider, 1997; Xie et al., 2003; although see Henington et al., 1998). In fact, studies that include measures of both physical and relational aggression report almost equal proportions of aggressive boys and girls (Crick and Grotpeter, 1995; Rys and Bear, 1997).

Evidence suggests that, like physical aggression, some children respond to experiences of provocation with relationally aggressive conduct (Little et al., 2003). It is possible that, as proposed with physical aggression (Scarpa and Raine, 1997), cardiovascular reactivity serves as an energizer that facilitates relationally aggressive responding to provocation. Alternatively, individuals exhibiting relatively low levels of cardiovascular arousal may engage in relational aggression as a means of increasing their arousal to more optimal levels. In the present study, the associations between cardiovascular reactivity while discussing an experience of provocation and both physical and relational aggression were assessed.

Finally, cardiovascular reactivity to provocation may predict different forms of aggression for boys and girls. Powch and Houston (1996) suggest that cardiovascular arousal may be less likely to be associated with physical aggressiveness in females than in males because females inhibit physically aggressive behaviors given their socialization away from such conduct. From this perspective, girls and boys who exhibit heightened cardiac reactivity may employ aggressive behaviors that are relatively normative and effective in the context of their gender-

segregated peer groups (Crick and Grotpeter, 1995). Thus, cardiovascular reactivity may promote aggressive conduct in both boys and girls, but the manifestation of aggression may differ by gender. Consistent with this proposal, it was expected that heightened cardiac reactivity while discussing a relational provocation would more strongly predict involvement in *relational* aggression for girls and *physical* aggression for boys.

In sum, goal of this paper was to examine the association between cardiovascular reactivity while recounting an experience of relational provocation and aggressive behavior patterns. It was predicted that children would exhibit heightened cardiovascular activity while discussing a relational provocation and that this reactivity would be greater for girls than for boys. In addition, heightened BP reactivity was expected to be associated with increased levels of physical and relational aggression. Given the mixed findings regarding HR, no specific predictions regarding the direction of effects were made. Finally, it was hypothesized that gender would play an important role in the association between cardiac reactivity and aggression. Specifically, cardiovascular reactivity was expected to predict different forms of aggression for boys and girls: it was hypothesized that reactivity would more strongly predict relational aggression for girls and physical aggression for boys.

1. Method

1.1. Participants

Ninety-five 5th grade students were recruited from a total of 8 classrooms in two suburban, Midwestern schools. Of these, 18 participants were excluded from analyses because they did not complete the interview or the baseline assessments (11 did not complete the interview due to language difficulties or refusal to answer questions; baseline physiological measures following the interview were not assessed for 5 participants due to experimenter error and 2 participants due to equipment malfunction). Thus, the final sample consisted of 77 participants (57% female). Each participant had parental consent to participate. The socioeconomic status of participants was estimated to be middle to upper-middle class based on school demographic information. Specifically 16% of students at the first school and 4% of students at the second school were eligible for reduced price or free lunches.

Fifth-graders were chosen for the present study because the methods employed (e.g., the Social Competence Interview) have been shown to be reliable and valid in this age group and because research indicates that relationally aggressive behaviors are increasing in frequency for girls during this developmental period (Murray-Close et al., 2007). Eighty percent of the sample was European-American, 7% was Latino, 2% was African-American, and 11% represented other ethnic groups.

1.2. Procedure

Resting cardiac arousal, cardiovascular reactivity, height, and weight were assessed during a 20-minute individual

interview. Participants were escorted from class to a quiet room by a trained female research assistant. The interviewer explained the experimental procedure and the child provided assent to participate. Given research suggesting that body bulk is associated with aggressive behavior (Raine et al., 1997), analyses assessing the association between reactivity and aggression controlled for body mass index (BMI). Thus, height and weight were recorded at this time so that BMI could be calculated.

Following height and weight measurements, participants were asked to be seated and a standard occluding cuff of the appropriate size was attached to their arm. Participants were asked to relax quietly for 1 min before the first baseline assessment. During the first phase of the interview (Baseline 1), participants were asked to sit quietly and relax as their BP and HR were assessed. Three readings were taken at two-minute intervals. During the second phase of the interview, participants completed the Social Competence Interview (SCI), while their HR and BP were assessed every 2 min. Finally, following administration of the SCI, participants completed a second baseline assessment (Baseline 2), during which time BP and HR were measured three times at two-minute intervals.[1] Participants were thanked for their time, provided with a small gift for their cooperation (e.g., a pencil), and escorted back to class. Finally, teachers provided reports of children's aggression and anxious/depressed symptoms. Teachers were compensated $60 for completing the teacher-report measures.

1.3. Interview session

1.3.1. Physiological measures

BP and HR were assessed using a Dinamap Vital Signs Monitor (Model 8100, Critikon, Tampa, FL). This monitor assesses both systolic BP and diastolic BP. In addition, HR is measured during cuff deflation. Dinamap monitors provide cardiovascular readings that closely resemble more invasive methods (e.g., intra-arterial recordings), and these monitors are common in psychophysiological studies (Ewart et al., 1998). Moreover, evidence suggests that physiological measurements from methods such as cuff occlusion predict antisocial conduct as well as those obtained from more sophisticated methodologies (Ortiz and Raine, 2004).

1.3.2. Social competence interview

Participants completed a semi-structured, 12-minute interview adapted from a procedure developed by Ewart and colleagues (the SCI; e.g., Ewart and Kolodner, 1991, 1994; Ewart et al., 1998). Although the SCI was originally intended for use with adolescent samples (generally 13 and older), recent research suggests that the instrument may be used with children

as young as 8 (e.g., Chen et al., 2002). During the first 2 min of the SCI, participants are given a stack of index cards describing stressful situations that students frequently report (e.g., interactions with peers, family relations, etc.). Participants are then asked to choose a problem or stressor that they themselves have recently experienced. During minutes 2–7 of the interview, participants are asked to describe the problem in detail. Interviewers ask participants to recount their thoughts and emotions concerning the incident. Finally, during minutes 7 to 12, participants engage in social problem-solving tasks regarding the social stressor. Throughout the entire SCI, participants' HR and BP are monitored. Results of previous research indicate that participants reliably exhibit increases in BP when talking about social stressors relative to other, non-social tasks (e.g., Ewart and Kolodner, 1991), and that there are meaningful individual differences in who exhibits the greatest spikes in BP when discussing these stressors (e.g., Ewart et al., 1998).

In the adaptation of the SCI used in the present study, the SCI focused on relational stressors. At the beginning of the SCI, the participant was given a deck of five cards. On each card, a category of relational conflict situations was described (e.g., "other kids talk about you behind your back"; "you don't get invited to something") and participants were asked to read each card and think about times when the problem described on the card happened to them. Participants were instructed to choose the problem that they found most stressful to discuss.

Following the procedures developed by Ewart and Kolodner (1991), participants were asked to describe a specific instance when the problem arose (e.g., what happened, where and when it happened, who was present, what the child said and did, what the peer(s) said and did, what happened as a result, etc.). The interviewer helped the child reconstruct the event using standard probe questions, guided imagery, and reflective listening techniques (Ewart and Kolodner, 1991). Interviewers were female undergraduate students in Psychology or Developmental Psychology. All interviewers underwent at least 25 h of training in the SCI prior to interviewing research participants. In addition, approximately 20% of interviews were observed by a graduate student trained by Dr. Ewart, and feedback regarding the administration of the SCI was provided. It is important to note that the categories of conflict used in previous SCI research represent different (although related) domains than those proposed here (i.e., relational peer conflicts). This change was made to allow for a more sensitive assessment of girls' reactions to peer conflict. In addition, given the focus on physiological reactivity to relational stressors, only physiological readings taken while participants were recounting the relational stressor were included when assessing physiological activity during the SCI.

1.3.3. Physiological data reduction

Physiological measures of BP and HR during periods of rest were aggregated to yield a baseline systolic BP, baseline diastolic BP, and baseline HR score for each participant.

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[1] Although the baseline was computed by including both pre- and post-SCI physiological measurements, all findings except one were replicated when only the pre-SCI resting period measurements were used to compute the baseline. Specifically, the increase in systolic BP reactivity during the SCI was no longer significant when only the pre-SCI measurements were used for the baseline.

Baseline scores were computed by averaging five of the six baseline measurements. The first baseline measurement was dropped (Ewart and Kolodner, 1993; Pine et al., 1996) because it can reflect artifacts such as the child adjusting to the occluding cuff. In cases where a baseline measure was missing (due to equipment malfunction, $N=3$) the remaining baseline measures were averaged to yield a baseline score for these participants. Cardiovascular arousal during the SCI was computed by averaging the SCI readings during the first portion of the interview for systolic BP, diastolic BP, and HR, respectively. Baseline cardiovascular arousal was then subtracted from SCI arousal, yielding systolic BP reactivity, diastolic BP reactivity, and HR reactivity scores, respectively (Ewart and Kolodner, 1991).

1.4. Teacher report

1.4.1. Aggression

A teacher-rating measure, Children's Social Behavior Scale-Teacher Report, was used to assess teacher reports of children's aggression (Crick, 1996). This instrument consists of three subscales: relational aggression (7 items; e.g., "This student spreads rumors or gossips about some peers"), physical aggression (4 items; e.g., "This student hits, pushes, or shoves peers"), and a prosocial behavior scale with 4 items serving as positively-toned filler items.

Teachers responded to the items on the teacher instrument by rating on a 5-point scale how true each item was for each of their participating students. Favorable psychometric properties of this instrument have been demonstrated in prior research (e.g., Crick, 1996). Specifically, factor analysis has confirmed the existence of the three hypothesized factors (relational aggression, physical aggression, and prosocial behavior). Evidence for the construct validity has also been demonstrated through correlations of $r=.60$, $p<.001$, and $r=.72$, $p<.001$, between peer and teacher measures of relational and physical aggression, respectively. Finally, teachers' responses to this measure have been shown to be reliable with Chronbach's alpha greater than .90 for both aggression scales. In the present sample, the instrument demonstrated high internal consistency, with $\alpha=.96$ for physical aggression and $\alpha=.95$ for relational aggression.

1.4.2. Anxiety and depression

To address the hypotheses of the present study, it is important to control for factors that may confound the relations between gender, cardiac arousal, and aggression (e.g., Raine et al., 1997). One potentially important confound is children's levels of anxiety and depression. Many researchers have noted the importance of considering anxiety and depression when examining correlates of physiological activity because they are related to physiological arousal during rest and periods of stress (Ewart and Kolodner, 1994; Herpertz et al., 2003; Knight and McCallum, 1998; Light et al., 1998; Mathias and Stanford, 2003; Matthews et al., 2005; Ortiz and Raine, 2004; van Goozen et al., 1998; Wilken et al., 1999). Many children exhibit aggression in combination with anxiety (e.g., Lambert et al.,

2001) and depression (e.g., Messer and Gross, 1994); as such, analyses in the present study controlled for anxious/depressed symptoms so that the unique relation between cardiac reactivity and aggression could be assessed.

Teacher reports of participants' anxious/depressed symptoms were assessed using the Teacher Report form of the Child Behavior Checklist (TRF; Achenbach and Edelbrock, 1991). Teacher reports were selected because they avoid self-serving biases found with self-reports of such experiences during this developmental period (Crick, 1997). Teachers were presented with 18 items describing symptoms of anxiety and depression (e.g., "Unhappy, sad, or depressed"). Teachers rated how true each item was of participants on a scale from '0' (not true) to '2' (very true or often true). Students' scores were summed across items to yield a total anxious/depressed score (the item assessing suicidal ideation was dropped for ethical reasons). This scale was highly reliable in the present sample, with $\alpha=.90$.

1.5. Transforming skewed data

Prior to running analyses, the distributions of physical and relational aggression were visually inspected and statistics assessing skewness were examined. The results indicated that relational aggression and physical aggression were both positively skewed. An inverse transformation was conducted on these variables to address these data considerations. These transformations successfully eliminated skewness in relational aggression and substantially reduced the skewness of physical aggression. As such, all analyses were conducted using the transformed data.

2. Results

2.1. Gender differences in physiological reactivity to relational stress

The first goal of the present paper was to assess cardiovascular reactivity to the SCI. Participants were expected to exhibit increases in BP and HR during the interview, and it was hypothesized that these increases would be greatest for girls. To examine whether children exhibit heightened cardiac arousal while discussing relational provocation and to explore whether this effect was moderated by gender, three repeated measures analysis of variance (RM-ANOVA) analyses for systolic BP, diastolic BP, and HR, respectively, were run. In each model, Time (Time 1=cardiac arousal at baseline and Time 2=cardiac arousal during the SCI) served as the within-subject factor and gender served as the between-subject factor. These analyses allowed for a test of whether children exhibit increased cardiovascular arousal during the SCI and whether this reactivity is greater for females than for males.

The results of these analyses, presented in Table 1, indicated that children exhibited increased cardiovascular arousal during the SCI relative to baseline measures. Specifically, the results revealed a significant increase in children's systolic BP, $F(1, 75)=14.41$, $p<.001$, diastolic BP,

Table 1
Mean (and SD) cardiovascular arousal during baseline and during the SCI for boys and girls

| Measure | Gender | Time | | F rations | | |
		Baseline	SCI	Time	Gender	Time × gender
SBP	Boys	109.41 (10.00)	112.87 (11.61)	14.41***	ns	ns
	Girls	105.60 (8.49)	110.43 (10.29)			
	Total	107.24 (9.30)	111.48 (10.87)			
DBP	Boys	55.82 (8.17)	61.75 (9.40)	93.37***	ns	5.07*
	Girls	55.65 (8.09)	65.17 (7.95)			
	Total	56.25 (7.94)	63.87 (7.73)			
HR	Boys	84.37 (10.89)	88.64 (10.59)	81.71***	ns	ns
	Girls	80.88 (11.86)	86.95 (11.04)			
	Total	82.37 (11.51)	87.68 (10.81)			

*$p < .05$; ***$p < .001$.
Note. SBP = systolic blood pressure and DBP = diastolic blood pressure.

$F(1,75) = 93.37$, $p < .001$, and HR, $F(1, 75) = 81.71$, $p < .001$, from baseline to SCI. The increase in diastolic BP was moderated by gender, $F(1, 75) = 5.07$, $p < .05$. Follow-up RM-ANOVAs run separately by gender indicated that both boys, $F(1, 31) = 30.64$, $p < .001$, and girls, $F(1, 43) = 71.35$, $p < .001$, exhibited increases in diastolic BP during the interview; however, the increase was larger for girls than for boys (see Table 1).

2.2. Cardiovascular reactivity and aggression

The second goal of the present paper was to examine whether physiological reactivity while discussing relational provocation predicted aggression and whether this effect was moderated by the participant's gender and the form of aggression under consideration. Descriptive data for the aggression and cardiovascular reactivity variables are presented in Table 2. It was hypothesized that BP reactivity while discussing relational provocation would predict heightened aggression; in contrast,

no directional hypotheses were made regarding the association between HR reactivity and aggression. Overall, it was expected that reactivity would more strongly predict *relational* aggression for girls and *physical* aggression for boys. To address these hypotheses, two separate sets of hierarchical regression analyses were conducted.

In the first set of three regressions, relational aggression was regressed onto systolic BP reactivity, diastolic BP reactivity, and HR reactivity, respectively. In each regression, anxiety/depression and BMI were entered at Step 1 to control for these potential confounds. Physiological reactivity was entered at Step 2. Finally, to investigate whether the association between cardiovascular reactivity and aggression differed for boys and girls, gender (male = -1; female = 1) and the interaction between gender and reactivity were entered at Step 3.

The results, presented in Table 3, indicated that, as expected, anxiety/depression scores were positively associated with children's involvement in relational aggression. Surprisingly, there were no gender differences in teacher-reported relational

Table 2
Mean (and SDs) of aggression and reactivity (along the diagonal) and correlations among variables (on the off-diagonal) for males and females

Measure	1.	2.	3.	4.	5.
Total sample					
1. Physical aggression	5.22 (2.96)				
2. Relational aggression	.43***	8.96 (5.21)			
3. Systolic BP reactivity	−.05	.14	4.24 (9.23)		
4. Diastolic BP reactivity	−.13	−.01	.36**	7.98 (7.13)	
5. Heart rate reactivity	−.25*	−.19†	.09	.32**	5.30 (5.02)
Males					
1. Physical aggression	6.30 (3.64)				
2. Relational aggression	.75***	8.12 (4.75)			
3. Systolic BP reactivity	−.11	−.14	3.46 (8.54)		
4. Diastolic BP reactivity	−.02	.02	.22	5.93 (6.15)	
5. Heart rate reactivity	−.35*	−.33†	−.32†	.19	4.28 (5.06)
Females					
1. Physical aggression	4.41 (2.00)				
2. Relational aggression	.34*	9.59 (5.50)			
3. Systolic BP reactivity	.10	.29†	4.82 (10.11)		
4. Diastolic BP reactivity	−.08	−.10	.42***	9.53 (7.48)	
5. Heart rate reactivity	.01	−.15	.34*	.35*	6.07 (4.90)

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$.

Table 3
Association between cardiovascular reactivity to relational stress and relational aggression

Model	Step	Predictor	β	T-value	R^2, $\triangle R^2$	F, $\triangle F$
1	1	BMI	.03	.30	.20	9.40***
		Anxiety/depression	.45***	4.33		
	2	Systolic BP reactivity	.12	1.13	.01	1.28
	3	Gender	.13	1.32	.07	3.61*
		Gender × systolic BP reactivity	.24*	2.23		
2	1	BMI	.03	.30	.20	9.40***
		Anxiety/depression	.45***	4.33		
	2	Diastolic BP reactivity	−.01	−.07	.00	.00
	3	Gender	.17	1.54	.04	1.67
		Gender × diastolic BP reactivity	−.09	−.86		
3	1	BMI	.03	.30	.20	9.40***
		Anxiety/depression	.45***	4.33		
	2	HR reactivity	−.12	−1.12	.01	1.26
	3	Gender	.21†	1.96	.05	2.18
		Gender × HR reactivity	.11	1.07		

†$p<.10$; *$p<.05$; ***$p<.001$.

Table 4
Association between cardiovascular reactivity to relational stress and physical aggression

Model	Step	Predictor	β	T-value	R^2, $\triangle R^2$	F, $\triangle F$
1	1	BMI	.01	.07	.10	3.88*
		Anxiety/depression	.31**	2.79		
	2	Systolic BP reactivity	−.07	−.07	.01	.38
	3	Gender	−.40***	−3.85	.16	7.76**
		Gender × systolic BP reactivity	.13	1.15		
2	1	BMI	.01	.07	.10	3.88*
		Anxiety/depression	.31**	2.79		
	2	Diastolic BP reactivity	−.13	−1.16	.02	1.35
	3	Gender	−.38**	−3.59	.14	6.46**
		Gender × diastolic BP reactivity	−.03	−.30		
3	1	BMI	.01	.07	.10	3.88*
		Anxiety/depression	.31**	2.79		
	2	HR reactivity	−.20†	−1.81	.04	3.27†
	3	Gender	−.31**	−3.18	.18	9.60***
		Gender × HR reactivity	.25*	2.40		

†$p<.10$; *$p<.05$; **$p<.01$; ***$p<.001$.

aggression (although note that this effect approached statistical significance in the third regression, $p<.06$). However, the interaction between systolic BP reactivity and relational aggression was significant. Follow-up simple slope analyses (see Cohen et al., 1993) revealed that systolic BP reactivity was positively associated with relational aggression for girls, $t(69)=1.99$, $p<.05$. In contrast, systolic BP reactivity was not significantly related to relational aggression scores for boys, $t(69)=−.79$, n.s. Relational aggression scores among males and females low in systolic BP reactivity (1 SD below the mean) and high in systolic BP reactivity (1 SD above the mean) are presented in Fig. 1. No other effects in the regressions were significant.

In the second set of three regressions, physical aggression was regressed onto systolic BP reactivity, diastolic BP reactivity, and HR reactivity, respectively. In each regression, anxiety/depression and BMI were entered at Step 1 to control for
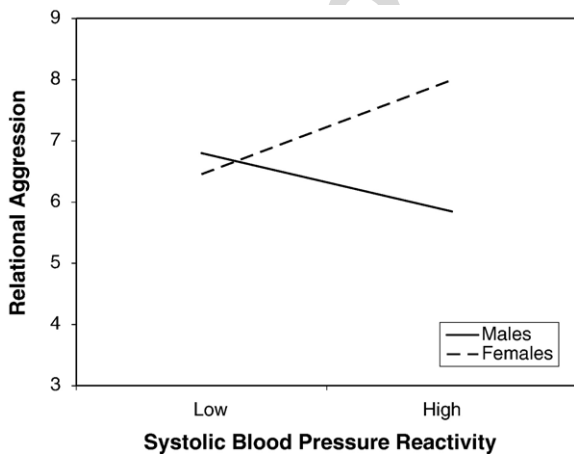
these potential confounds. Physiological reactivity was entered at Step 2. Finally, gender and the interaction between gender and reactivity were entered at Step 3. The results, presented in Table 4, indicated that, as expected, anxiety/depression scores were positively associated with children's involvement in physically aggressive behaviors. In addition, the effect of gender was significant, with boys exhibiting greater levels of physical aggression than girls. The association between HR reactivity and physical aggression approached conventional levels of statistical significance ($p<.10$), with higher HR reactivity predicting lower levels of physical aggression. The interaction between gender and HR reactivity was also significant. Simple slope analyses indicated that HR reactivity was associated with lower physical aggression scores among boys, $t(69)=−2.68$, $p<.01$. In contrast, HR reactivity was not related to physical aggression among girls, $t(69)=.04$, n.s (see Fig. 2). Physical aggression scores among males and females

Fig. 1. Association between systolic blood pressure reactivity (low=1 SD below the mean and high=1 SD above the mean) and relational aggression in males and females.
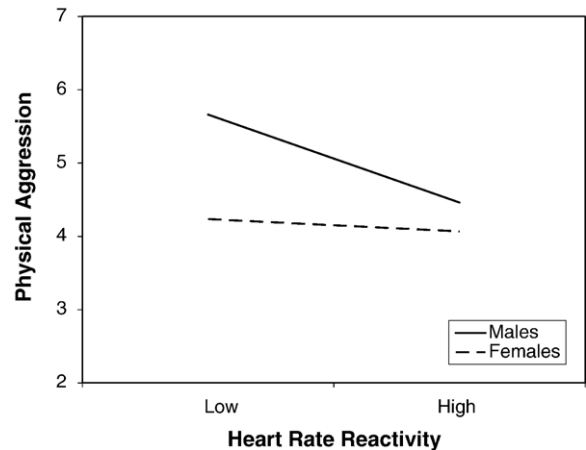

Fig. 2. Association between heart rate reactivity (low=1 SD below the mean and high=1 SD above the mean) and physical aggression in males and females.

low in HR reactivity (1 SD below the mean) and high in HR reactivity (1 SD above the mean) are presented in Fig. 2.

3. Discussion

The goal of this study was to explore the association between cardiovascular reactivity while recounting an experience of relational provocation and physical and relational aggression. Relational provocations were chosen in the present investigation to allow for a more sensitive test of the association between cardiac reactivity and aggression among girls. Consistent with previous work, participants exhibited heightened cardiovascular arousal (i.e., HR, systolic BP, and diastolic BP) while recounting a relational stressor (Ewart and Kolodner, 1991). Moreover, there was partial support for the hypothesis that girls would be especially reactive to discussing a relational provocation; specifically, increases in diastolic BP during the interview were greater for girls than for boys. These findings suggest that discussing a relational provocation led to increases in cardiac activity among participants, particularly females.

The results of the present study provided support for the hypotheses that cardiac reactivity would predict both relationally and physically aggressive behavior patterns and that the relation between reactivity and aggression would be sex-specific. For girls only, systolic BP reactivity was associated with heightened relational aggression. This finding is consistent with the idea that heightened cardiovascular reactivity energizes aggressive responding to provocation, and may reflect an exaggerated fight/flight response to relational provocation among girls. In other words, girls who exhibit heightened cardiac arousal in response to relational provocation may be at risk for engaging in relationally aggressive conduct.

In contrast, HR reactivity was *negatively* associated with physical aggression among boys. This finding is consistent with the perspective that cardiac underarousal is associated with heightened aggression (Raine, 2002) and suggests that the association between underarousal and aggression may be evident in studies of cardiovascular reactivity in addition to studies focusing on resting arousal. Alternatively, this finding may reflect the particular stressor used to elicit cardiovascular responses in participants. Specifically, relational provocations were selected to allow for a sensitive test of the relation between cardiovascular reactivity and aggression among girls. Most previous research that has found a positive association between cardiovascular reactivity and aggression in boys has focused on instrumental stressors (e.g., losing a computer game, Waschbusch et al., 2002; being told a peer wants to pick a fight with you; Williams et al., 2003). It is possible that physically aggressive boys may be particularly reactive to instrumental stressors but relatively unresponsive to relational provocations. In other words, the stressor assessed in the present study may be relatively upsetting for nonaggressive boys but not salient for boys who engage in high levels of physically aggressive conduct. To address this possibility, future research would benefit from measuring cardiac reactivity to both relational and instrumental provocations.

An important implication of the moderating role of gender in the association between cardiovascular reactivity and aggression is that biological and physiological vulnerabilities for aggressive conduct may result in different manifestations of behavior in males and females. This is consistent with the developmental psychopathology concept of multifinality, in which a particular risk factor does not lead to the same outcome in every individual (Sroufe, 1997). The findings suggest that a focus on gender may help clarify questions regarding multifinality in children's trajectories toward behavior problems. In other words, gender may be an important factor in the types of behavioral outcomes associated with particular risk factors such as cardiovascular reactivity.

Another important implication of these findings is that different measures of cardiovascular reactivity (systolic BP, diastolic BP, and HR) may yield quite different results. For example, although systolic BP reactivity was *positively* associated with relational aggression for girls, HR reactivity was *negatively* related to physical aggression for boys. These results are consistent with previous research suggesting that BP reactivity predicts heightened aggression (e.g., Gump et al., 1999) whereas HR reactivity is sometimes related to low levels of aggression (e.g., Kibler et al., 2004). In addition, although systolic BP reactivity was associated with relational aggression among girls, diastolic BP and HR reactivity did not predict relationally aggressive behaviors in males or females. One possible explanation for this pattern of results is that the interview method used in the present study more reliably elicits stable individual differences in systolic BP reactivity than other cardiovascular indices. Consistent with this proposal, Ewart and Kolodner (1991) found that systolic BP reactivity to the SCI was more reliable over a six-month period than diastolic BP reactivity or HR reactivity. These researchers proposed that systolic BP reactivity to the SCI may capture an enduring tendency to exhibit increased cardiac arousal when encountering stressful interpersonal situations, whereas diastolic BP reactivity and HR reactivity may depend more on the specific situation encountered. As such, this may be a preferable method of assessing cardiac reactivity to relational provocation when using the SCI.

An alternative explanation for these findings is that relational aggression in females is related to specific processes that affect BP. BP is influenced by a number of underlying processes, including cardiac output and peripheral resistance. Some researchers have suggested that, when discussing social stressors, systolic BP reactivity may reflect heightened cardiac output whereas diastolic BP reactivity may reflect increased vascular resistance (e.g., Ewart and Kolodner, 1993). Moreover, these distinct underlying processes may be related to different appraisals of stressful situations (Tomaka et al., 1993) with unique implications for physiological activity (Tomaka et al., 1993). To address this possibility, additional studies including physiological assessments of cardiac output and peripheral resistance in response to relational stressors are necessary.

3.1. Limitations and future directions

Despite the interesting findings of the present study, a number of important limitations must be acknowledged. First,

the sample size in this study was relatively small; as such, the power to detect significant relations among variables was limited. Although the results of the present study suggest that cardiovascular reactivity is associated with aggression in gender-specific ways, future research with larger sample sizes is necessary to clarify which indices of cardiovascular reactivity predict relational and physical aggression in males and females. In addition, the relative lack of racial diversity in the sample raises questions regarding the generalizability of the findings. Greater confidence in these results would be warranted if they were replicated with larger, more diverse, and more representative samples.

Second, proactive and reactive forms of physical and relational aggression were not assessed in the present investigation. A number of researchers have proposed that physiological reactivity to provocation will be associated with reactive aggression (Hubbard et al., 2002; McBurnett et al., 2005; Rappaport and Thomas, 2004; Scarpa and Ollendick, 2003; Scarpa and Raine, 1997). Reactive aggression consists of aggressive displays enacted in anger following perceived negative experiences such as provocation or frustration (Crick and Dodge, 1996). Reactive aggression is hypothesized to relate to increases in physiological arousal following negative experiences or situations (Hubbard et al., 2002; McBurnett et al., 2005; Scarpa and Ollendick, 2003; Scarpa and Raine, 1997), and thus is most consistent with the prediction that heightened cardiac reactivity will be associated with aggression. In contrast, proactive aggression, defined as relatively non-emotional aggressive behaviors enacted with the purpose of attaining a desired goal (Crick and Dodge, 1996), may be most strongly related to chronic underarousal (Scarpa and Raine, 1997). It is possible that the findings of the present study are complicated by the failure to assess these different forms of aggression. Moreover, although studies have found that teacher reports are highly correlated with peer reports of physical and relational aggression (Crick, 1996), additional research may benefit from including multiple informants of aggressive conduct. Future research assessing both subtypes of physical and relational aggression from multiple informants would help clarify this important point.

Another limitation of this study was the assessment of physiological reactivity to relational provocations. Although participants exhibited increases in HR and BP in response to the SCI, this methodological approach has two important limitations. First, participants may have imagined or fabricated experiences of relational provocation during the SCI. The study was designed with the goal of reducing this possibility (e.g., interviewers were explicitly directed not to pressure participants to come up with experiences to discuss; participants were asked to recount experiences in extensive detail on-the-spot); nevertheless, it remains possible that some participants reported provocations that did not actually happen. Second, participants' cardiovascular reactivity to recounting a provocation may differ from their reactivity while actually experiencing the event. Future research may benefit from experimental manipulations of relational provocation in the laboratory (e.g., telling participants that another child does not like them and does not

want to play with them). This would provide a uniform experience of relational provocation to all participants and allow experimenters to measure cardiac activity during the actual experience rather than while reliving the provocation. This approach would also eliminate the concern that participants may fabricate experiences of provocation to discuss. In addition, research assessing HR and BP throughout the course of a normal day (see Ewart and Kolodner, 1994) may allow for on-line measurement of cardiovascular reactivity to real-life stressors. Converging evidence from a number of research designs would bolster the confidence in the results of this investigation.

3.2. Conclusions

The findings from the present study indicate that cardiovascular arousal following provocation is related to children's physical and relational aggression. However, different patterns of results emerged for girls and for boys. Specifically, among girls, systolic BP reactivity while discussing relational provocation was associated with heightened relational aggression. In contrast, for boys, HR reactivity was associated with lower physical aggression. Taken together, these findings suggest that the association between cardiovascular reactivity and aggression depends on the gender of the participant and the type of aggression assessed.

The results of the present study have important implications regarding our understanding of the development of aggressive conduct among girls. To date, little work has focused on potential biological contributors to relational aggression, and studies assessing the role of physiological activity may help ameliorate this important limitation. Moreover, a focus on physiological contributors to aggression may inform interventions aimed at reducing children's involvement in such conduct. For example, interventions with relationally aggressive girls may benefit from helping girls develop self-soothing skills to reduce physiological arousal following stress. For boys, interventions may instead focus on coaching regarding appropriate alternatives to aggression for raising one's physiological arousal to desirable levels (e.g., rock climbing; Ortiz and Raine, 2004). In this regard, attention to the role of cardiovascular reactivity in relationally, as well as physically, aggressive conduct may allow for early identification and improved treatment of both boys girls who are at risk for engagement in aggression.

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