Emotional and Cardiovascular Responses to Adults' Angry Behavior and to Challenging Tasks in Children of Hypertensive and Normotensive Parents

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Ballard, Mary E.; Cummings, E. Mark; and Larkin, Kevin. *Emotional and Cardiovascular Responses to Adults' Angry Behavior and to Challenging Tasks in Children of Hypertensive and Normotensive Parents.* Child Development, 1993, 64, 500–515. Cardiovascular, overt-motor, and verbal-reported responses to interadult emotional expressions, including anger, and to challenging task situations were examined in a sample of 49 10–14-year-old children of hypertensive (EH) and normotensive parents (NT). Sons of EH parents showed greater systolic blood pressure reactivity to interadult anger and to the digit span task than sons of NT parents. A consistent pattern was not found for girls. Marital distress and overt maternal anger expression predicted verbal-reported and overt-motor responses to interadult anger. Family history of EH and sex did *not* predict these responses. Implications include (*a*) heightened systolic blood pressure response to stress may be found in sons of EH parents before they are diagnosed to have EH disorders, (*b*) relations between family history of EH and cardiovascular response may be sex moderated, and (*c*) vulnerability to stress may be related to *specific* familial histories and backgrounds.

Anger between adults is a commonly occurring event in the everyday lives of children. Children are sensitive to angry expressions by parents (e.g., Crockenberg, 1985; Cummings, Zahn-Waxler, & Radke-Yarrow, 1981) and can differentiate between different forms of conflict expression (e.g., verbal, nonverbal, verbal-physical) (Ballard & Cummings, 1990; Cummings, Vogel, Cummings, & El-Sheikh, 1989) and as to whether conflicts are resolved (Cummings, Ballard, El-Sheikh, & Lake, 1991). Within certain ill-defined bounds, exposure to adults' angry behavior is unlikely to be a cause for concern and may even be a positive experience that teaches children valuable lessons with regard to how to handle the inevitable conflicts of life. On the other hand, exposure to high levels of family discord is associated with the development of a variety of problems in children (see review in Grych & Fincham, 1990). Further, repeated exposure to anger has been associated with heightened emotional and behavioral reactivity to anger (e.g., Cummings, Pellegrini, Notarius, & Cummings, 1989; Cummings, Iannotti, & Zahn-Waxler, 1985).

However, research on the effects of exposure to anger on children has been limited in terms of the populations studied and the response variables assessed. In describing a model for a process-oriented study of children's responses to interadult anger, Cummings and El-Sheikh (1991) stressed the importance of studying the responses of children from a variety of risk groups, as well as normal samples, for understanding the full range of effects associated with exposure to adults' angry behavior. The present study examines responses in a heretofore uninvestigated group: children of parents with essential hypertension (EH). Further, exposure to parental and familial anger has usually been thought of in terms of risk for behavior problems in children, but this may be too narrow a view. That is, exposure to anger may also elicit problematic response

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patterns that are not classifiable as behavior problems per se. Specifically, another area of concern might be undesirable effects of exposure to high levels of anger on children's cardiovascular functioning. The cardiovascular responsivity of young children to adults' angry behavior has been demonstrated (El-Sheikh, Cummings, & Goetsch, 1989). In the present research, the focus is on children's cardiovascular reactivity to anger, with a specific focus on cardiovascular responding in children of parents with essential hypertension.

Children of EH parents are at risk for the development of EH (Paffenbarger, Thorne, & Wing, 1968; Page, 1983). However, it is uncertain whether this risk constitutes a genetic predisposition, a unique environmental influence, or some combination of the two. Because children of EH parents do not show higher resting blood pressure than children of nonhypertensive parents, it has become commonplace to investigate their cardiovascular reactions to standard behavioral challenges (Falkner, Onesti, Angelakos, Fernandes, & Langman, 1979; Falkner & Ragonesi, 1986). These cardiovascular measures provide a unique source of information that cannot be inferred by resting levels alone. Investigations of cardiovascular response to behavioral stressors are important in light of prospective evidence suggesting that individuals with exaggerated heart rate and blood pressure reactions have a greater propensity for developing coronary heart disease (Keys et al., 1971) and EH (Menkes et al., 1990; Wood, Sheps, Elveback, & Schirger, 1984).

From studies comparing children differing in parental hypertensive status, there is some evidence that children of parents with EH show different patterns of coping with stress than children of normotensive (NT) parents and that these patterns are evident well before such children develop cardiovascular disease themselves. Findings relevant to this issue include studies indicating that (*a*) children of EH parents show greater cardiovascular reactivity to or during certain psychological stressors than children of NT parents (Falkner et al., 1979; Falkner & Ragonesi, 1986; Holroyd & Gorkin, 1983; McCann & Matthews, 1988) and (*b*) families that include EH parents evidence more negative nonverbal behavior during conflict situations than families with NT parents (Baer et al., 1983), with such behavior related to children's systolic blood pressure response (Baer, Vincent, Williams, Bourianoff, & Bartlett, 1980). Thus, these children's patterns of coping with anger and hostility may be a precursor of the development of later problems. If this is the case, such information might someday serve a useful role in early identification and intervention for children at risk for the development of hypertension.

Relatively few studies have been conducted on this general topic, however, and there have been no direct investigations of how children of parents with EH cope specifically with adults' angry behavior and how such coping patterns compare with responses to other psychological stressors. The available evidence suggests that cardiovascular reactivity tends to be consistent across stressors and contexts, even in children and adolescents (Matthews, Manuck, & Saab, 1986; Matthews, Rakaczky, Stoney, & Manuck, 1987). Further, there is evidence of sex differences in cardiovascular responding and in risk for the development of EH. Males consistently display higher systolic blood pressure responses than females by adolescence (e.g., Matthews et al., 1986; Murphy, Alpert, Willey, & Somes, 1988) and are more likely to develop EH, at least until late middle age (Rowland & Roberts, 1982; Stamler, Stamler, Riedlinger, Algra, & Roberts, 1976). It may be appropriate to think of these relations in terms of a family systems perspective rather than simply in terms of the behaviors of specific individuals. That is, certain patterns of handling expression of anger and hostility may impact not only the individual but family members exposed to these patterns of behavior, and the sex of individuals may be an important moderator of the nature of response patterns.

This study investigates the responses of children of EH and NT parents in multiple contexts, including exposure to interadult anger and several psychological challenges. Further, multiple dimensions of children's stress reactivity are examined, including cardiovascular (heart rate, systolic blood pressure, diastolic blood pressure), overt-motor, and verbal-reported responses. A fundamental tenet of a process-oriented approach to the study of anger is that coping processes are most informatively understood by viewing the multiplicity of contexts and dimensions in which children respond (Cummings & El-Sheikh, 1991). The present methodology is consistent with a "three-systems" (Lang, 1968) or "triple response mode" (Cone, 1979) position for the behavioral assessment of emotion. However, as eloquently argued by Kozak and Miller (1982), the collection of three-systems behavioral data (i.e., verbal-cognitive, overt-motor, somatic) constitutes a method, not the definition of a construct, and investigators must still attend to the theory that guides the research as well.

The focal construct in this study is reactivity to stress. However, reactivity is not necessarily a "unitary" phenomenon. For example, different dimensions of reactivity, including different cardiovascular responses (e.g., systolic blood pressure, heart rate), have been found to be independent or at least imperfectly correlated (Gunnar, 1987; Lang, 1968). Conceivably, the various forms of reactivity could have specific and very different correlates and etiologies in terms of family history. Family history of EH has been particularly related to heightened systolic blood pressure reactivity to stress, especially among boys. Since children of EH parents are not at any known greater risk for the development of behavior problems and emotional disorders, there is no reason to expect greater reactivity in these, or related, response dimensions. On the other hand, overt-motor and verbal-reported dimensions of reactivity have been linked with family history of marital conflict (e.g., E. M. Cummings et al., 1989; J. S. Cummings et al., 1989) and mode of conflict expression (e.g., Cummings, Ballard, & El-Sheikh, 1991; Cummings et al., 1981). Thus, one possibility is that the construct of reactivity associated with family history of EH is sex-linked and is limited to systolic blood pressure response, whereas other dimensions of reactivity are related to different dimensions of family background (e.g., level of marital discord, style of anger expression in the home). However, because there is little evidence directly pertinent to this issue, one can, alternatively, argue for a more unitary construct of reactivity as reflected more generally across multiple response dimensions and influenced simultaneously by various and multiple elements of family history and background.

Another issue, also relevant to an exploration of the construct of reactivity, is whether reactivity is shown only in certain contexts or is evidenced more generally across a variety of settings. For example, is heightened systolic blood pressure reactivity in children of EH parents evident only in response to socioemotional stressors or is greater reactivity also found in response to other categories of stress and challenge? Based on the evidence already described concerning children's and adults' consistency of responding across stressors, it might be expected that individuals demonstrating greater cardiovascular reactivity to anger will also show greater responsivity to other stressors, that is, patterns of relatively high cardiovascular response to stress would tend to be general, not specific, across contexts. However, only a limited set of stressors and challenges have been investigated to date, and it is unknown whether such effects will be found across contexts such as those to be investigated in the present study.

Method

Subjects

Participants were 25 children of parents with essential hypertension (12 girls and 13 boys) and 24 children of normotensive parents (12 girls and 12 boys) with a mean age of 12.5 years (SD = 1.4). The mean pubertal status level was 3.10 (SD = .86) on the five-point (1 = prepubertal, 5 = postpubertal) Pubertal Development Scale (Petersen, Crockett, Richards, & Boxer, 1988). The mean SES rating, as indexed by the Hollingshead (1975) Four Factor Index of Social Status, was 39.5 (SD = 17.0, range = 11–63), reflecting that SES ranged from Level 1 to Level 5, with a mean score on the border between Level 3 (e.g., sales workers, skilled craftsmen) and 4 (e.g., technical, medium business). The ANOVAs indicated no significant differences in age, pubertal level, or SES as a function of parental history of hypertension or sex. One child was Hispanic American and the remainder were non-Hispanic Caucasian Americans.

For the EH group, the EH parent was the father in 17 cases, the mother in seven instances, and both parents in one case. Parents in the EH group had been specifically diagnosed as EH by a physician. According to medication histories, most had been prescribed medication for EH at some time. If parents were at all uncertain as to their current blood pressure status, their blood pressure was checked. For the NT group, one of the following criteria was met: (*a*) both parents had received a blood pressure check by a physician within the last 2 years and were classified as NT or (*b*) both parents were tested by the first author and were found to be NT. For classification as NT, systolic blood pressure had to be 140 or less *and* diastolic blood pressure had to be 90 or less; if *either* blood pressure assessment was above these cutoffs, parents were not classified as NT. These criteria are consistent with stringent classification criteria in the psychophysiology literature and are considered generally reliable, although misclassification can occasionally occur (e.g., misdiagnoses by physician).

Most children (21 children of EH parents and 18 children of NT parents) came from intact two-parent families. Ten (four children of EH parents and six children of NT parents) came from single-parent homes. Two children of EH parents and one child of NT parents lived in two-parent homes consisting of the biological mother and a stepfather. One child of EH parents and one child of NT parents had been in intact adoptive two-parent homes since infancy. Since history of EH can be either a genetic and/or environmental risk factor (Sallis, Dimsdale, & Caine, 1988; Woodall & Matthews, 1989), the two children with nonbiological parents were included in the analysis and categorized according to the blood pressure status of the nonbiological parents. Noncustodial and stepparents were also screened for EH and as below.

Children with serious medical conditions (e.g., diabetes, heart attack, stroke, kidney failure) and children of parents with serious medical conditions (other than EH) that preexisted EH or serious psychopathology (e.g., severe depression, schizophrenia, alcoholism, other substance abuse problems) were not included. Initial screening for these conditions was by telephone, and final screening was based on a complete family medical history profile. Subjects were recruited from the community by means of fliers as well as from records of participants in other studies who had indicated a desire to be involved in additional research. Children were instructed not to consume any caffeine or nicotine or to engage in exercise for 3 hours prior to the experimental session.

Apparatus and Materials

Physiological recording.—Physiological equipment was located in a room adjacent to the subject. Blood pressure was monitored by means of an *IBS* electro-sphygmomanometer, with the appropriate size (child or adult) blood pressure cuff positioned on the nondominant arm. Blood pressure was monitored every 2 min. Research assistants, blind to the family history of hypertension of the subject, recorded the systolic and diastolic blood pressure readings for each measure for later entry into the computer.

Heart rate was recorded using a Grass Model 79D polygraph. To record heart-rate response, two electrodes were attached on the subject's right shoulder and one electrode was attached above the subject's left ankle (Andreassi, 1980). Heart rate was monitored continuously. Research assistants blind to the subjects' sex and parental history of hypertension later counted heart rate from the polygraph chart record on a minute-by-minute basis.

Taped verbal interactions.—Taped verbal interactions—with friendly, angry, and reconciliatory conditions—between an adult male and an adult female were taped in a recording studio while they were reading their parts from a script. Actors played the role of student research assistants for a psychology study. In one set of scripts the actors were concerned with "coding data" whereas in the other set the actors were interested in "running subjects." Each of the conditions lasted 4 min. Analyses indicated that there were no tape set effects. Children were not formally questioned with regard to the "believability" of the interactions, but children frequently volunteered that they thought the interactions were real, although a few said that they thought the interactions were coming from a TV, rather than being live. None of the children told investigators that they thought the interactions were part of the experiment.

Mirror tracing task.—In this task children traced a six-sided star using the star's mirror image to guide the pencil (Whipple Mirror Drawing Apparatus, Stoelting Company). A number of studies have used this task with children and adolescents, with the consistent finding that the task is generally perceived as frustrating (e.g., Matthews & Stoney, 1988; McCann & Matthews, 1988).

Digit span task.—Forward and backward digit span tasks based on the digit span task from the Wechsler Intelligence Scale for Children—Revised (WISC-R) were used. Serial subtraction tasks have often been used in studies of cardiovascular response in adolescents and adults. However, we were concerned that, due to the age range considered for the present study, stimulus equivalence would be difficult to achieve in a serial subtraction task via either equation or systematic variation of stimulus materials. Thus, the digit span task was chosen as a more appropriate cognitive-psychological stressor. Adequate test-retest reliability has been demonstrated for this age range for this task (.71–.84, Wechsler, 1974).

Marital distress.—Parents completed the Locke-Wallace Marital Adjustment Test (MAT). The MAT has acceptable reliability (Locke & Wallace, 1959) and validity (e.g., Birchler, Weiss, & Vincent, 1975; Gottman, Markman, & Notarius, 1977). Scores are typically dichotomized at 100, indicating whether the marriage is distressed (scores below 100) or nondistressed (scores above 100). The intercorrelation between parents' ratings for those families in which both parents completed marital adjustment measures ($N = 14$) was $r(13) = .68$, $p < .01$.

Parents also filled out the Straus Conflict Tactics Scale (CTS; Straus, 1979). The Physical Conflict Tactics (PCT) scale, which assesses parents' use of physical violence in marital disputes, was of particular interest. This has been shown to have adequate reliability, and there is evidence for its concurrent and construct validity (see Straus, 1979, for a summary). The intercorrelation between parents' scores ($N = 14$) was $r(13) = .88$, $p < .001$.

Scores on the MAT (J. S. Cummings et al., 1989) and PCT (J. S. Cummings et al., 1989; E. M. Cummings et al., 1989) have each been linked with children's responses to interadult anger.

Mothers' anger expression.—Parents also completed the State-Trait Anger Expression Inventory (STAXI, Spielberger et al., 1985). Since we were interested in obtaining an index of parents' overt expressions of anger, the anger-out (AX/Out) scale was pertinent to the present study. Both convergent and predictive validity have been demonstrated for this scale (e.g., Spielberger, 1988; Spielberger et al., 1985). While both fathers and mothers were asked to complete the STAXI, fathers' scores were not considered due to the limited number of fathers who completed forms.

Procedures

The procedures are outlined in Table 1. As shown, the social interactions were presented first, followed by the two laboratory stressors presented in counterbalanced order. The social interactions were administered first so that the initial instructions given to the subjects could be standardized and the ease and feasibility of the presentation of the procedures could be facilitated.

The parent accompanying the child was fully informed of the procedures and signed consent forms at the outset. Fathers brought in four of the children. The parent who accompanied the child filled out the forms at the laboratory whereas the other parent was asked to fill them out at home and return them by mail. The experimenter demonstrated the equipment in front of the child and then attached the equipment, as specified above.

The child was told that other studies were being conducted in adjoining laboratories and that people might be heard talking as they came and went from adjacent rooms. Children were informed that after 15–20 minutes they would be asked to complete some performance tasks (i.e., the mirror trac-

TABLE 1

OUTLINE OF PROCEDURES

Minute	Condition	Period
00–03	Adaptation	...
04–05	Friendly	1
06–07	Friendly	2
08–09	Angry	1
10–11	Angry	2
12–13	Reconciliation	1
14–15	Reconciliation	2
16–19	Rest	...
20–21	Mirror tracing	1[a]
22–23	Mirror tracing	2
24–27	Rest	...
28–29	Digit span	Forward
30–31	Digit span	Backward
32–variable	Interview	...
Variable	Baseline	...

NOTE.—Cardiovascular assessments were recorded for the beginning of the second minute of each period.

[a] The order of presentation of the mirror tracing and digit span tasks was counterbalanced across subjects.

ing and digit span tasks), but until that time they should relax and remain still. The child was then left alone in the room.

After a 1-min delay, cardiovascular assessments were taken for a 4-min adaptation period. No initial baseline was taken. Recent work suggests that anticipatory arousal preceding the presentation of stressful stimuli may preclude obtaining accurate initial baseline measures (e.g., Krantz & Manuck, 1984). Therefore, baseline readings were obtained following the experimental procedure (see Table 1). Another strategy that could be recommended would be to take baseline measurements before and after data collection and then compare them. However, adequate pre- and postbaseline assessments would not have been practical in the present study because of the already considerable length of the procedure, raising concerns about holding the attention and interest of the children.

Taped auditory interactions.—At the end of the 4-min adaptation period, a woman and a man carrying file folders and papers walked into the subject room. They acted surprised to see the subject and then walked out, closing the door. After entering an adjoining room they began the taped interactions by turning on a stereo tape player. The child heard the interactions through a vent between the rooms, making it sound as if the two confederates were actually engaging in a spontaneous conversation.

The interaction lasted 12 min, equally divided between friendly, angry, and resolved portions. The interaction was continuous, to increase realism. Further, also to increase realism, the actors' anger escalated gradually over the first minute and peaked during the second minute, making this minute of the interaction the most critical for analysis. The actors' anger began to deescalate near the end of the angry interaction, and the argument was quickly resolved at the beginning of the reconciliation segment. Following the reconciliation the actors left the adjoining room consistent with comments made on the taped interaction, and there was a 4-min recovery period in which the child was alone in the room.

Laboratory stressors.—Children then completed the mirror tracing and digit span tasks. Four minutes were devoted to each task, with a 4-min interval in between tasks (see Table 1). The order of presentation of the tasks was counterbalanced across subjects to control for order effects. Thus, half of the children completed the mirror tracing task first and half completed the digit span task first. Analyses indicated that order of presentation of these tasks had no effect on response. For the digit span task, 2 min were devoted to forward digit span and 2 min were given to backward digit span.

Interviews.—Next, children were interviewed concerning their emotional responses to the interactions following a procedure developed by E. M. Cummings et al. (1989). Children were first prompted to recall the interactions with the following statement: "Earlier there was a woman and a man talking in the next room. Do you remember hearing them? I would like to ask you a few questions about what you thought and how you felt while they were talking. Would that be okay? Please answer the questions as though you had been in the room with them." Without exception, children said that they recalled hearing the adults' interaction. Before questioning concerning each specific interaction, children were prompted to recall the interaction by reference to a salient topic that the adults discussed. For example, for the friendly interaction the statement was, "Do you remember when the woman and the man were talking about different movies that they had seen and saying what the movies were about?" With regard to each interaction children were asked, "How did you feel?" and "How much did you feel that way?" As described in E. M. Cummings et al. (1989), children were shown emotion faces of sad, scared, okay, mad, and happy emotions, asked to pick the emotion that represented how they felt, and then indicate on a five-point scale ranging from "very little" to "a whole lot" how much they felt that way.

Baseline.—Baseline cardiovascular levels were measured for 10 min at the end of the session after the last recovery period. To yield a more precise representation of subjects' actual resting heart rate and possible blood pressure, the lowest 6 min of heart rate response and the three lowest systolic and diastolic blood pressure measures (6 min of measurement) in this period were averaged to yield the final baseline assessment. This method for calculating baselines is consistent with the notion that baselines should reflect the lowest stable readings of psychophysiological response. Within the limits of feasibility for this study, this was judged to be an adequate procedure for obtaining representations of resting heart rate and blood pressure.

Finally, the physiological equipment was removed, and the participants were debriefed regarding the procedures and aims of this study.

Measurement: Behavioral Response to Adults' Angry Behavior

Children's behavioral responses were videotaped and coded according to whether behaviors were demonstrated at any time during the 4-min angry interaction. The coding system was based on the categories reported in Cummings (1987) and El-Sheikh et al. (1989). After extensive training, research assistants blind to subjects' group status coded the tapes. For the purposes of calculating interrater reliability, 24 sessions were coded by independent observers. Since the frequency of occurrence of many of the codes was low, a high percent-agreement index could be misleading as it may represent high agreement on the nonoccurrence of behavior. Accordingly, kappa was computed ($Po - Pc/1 - Pc$); these calculations were based on the occurrence/nonoccurrence of each individual behavior within the angry interaction period. Individual kappas for each individual code are presented in parentheses in the following paragraph.

The behaviors scored were as follows: freezing (1.00), postural distress (.64), verbal concern (1.00), verbal anger expression (1.00), facial distress (.54), mocking (.90), smiling (.92), and laughing (1.00).

Data Analysis: Cardiovascular Response

Blood pressure.—Systolic and diastolic blood pressure were measured once every 2 min via the automated cuff system. More frequent measurement can lead to spurious readings due to residual effects of cuff inflation on local circulation. For the emotion conditions, blood pressure readings were timed to occur at the beginning of the second and fourth minute of exposure to conditions, and there were therefore two measurements for each condition. Similarly, there were two measurements for each of the laboratory stress conditions.

Heart rate.—While heart rate was monitored continuously, the second and fourth minutes of heart rate were used for purposes of analyses to coincide with the timing of assessment of blood pressure. The entire minute of data was used. Movement artifact was seldom a problem and was handled by marking off the number of seconds obscured by movement and using the preceding segment of readable output for the same number of seconds to replace the unreadable data. Interrater agreement, calculated based on coding of 25% of the data by independent raters, was 93%.

Analysis plan: Cardiovascular response.—For analyses of response to emotion conditions, scores were entered for minutes 2 and 4 of exposure to each condition, resulting in six different values (Friendly 1, Friendly 2, Angry 1, Angry 2, Reconciliation 1, Reconciliation 2) for each child for systolic blood pressure, diastolic blood pressure, and heart rate. Similarly, for analyses of response to the laboratory stressors, scores were entered for minutes 2 and 4 of exposure to conditions (Digit Span 1, Digit Span 2, Mirror Tracing 1, Mirror Tracing 2).

To assess response to emotion conditions we conducted multivariate analyses of variance (MANCOVAs), with two between-subjects factors (parental EH status, sex), two within-subject factors (three levels of emotion conditions and two periods within each condition), and with the final baseline response as the covariate. To examine response to the laboratory stressors (digit span, mirror tracing), mixed-design ANCOVAs were performed. In these analyses, parental EH status and sex were between-subjects factors, the two periods within each task were within-subjects factors, and the final baseline was the covariate. For all analyses, significant interactions involving parental EH status × sex were followed up by a priori contrasts of parental EH status × sex for each period and, if appropriate, by simple effects tests contrasting response of groups, with the baseline as the covariate in these analyses as well.

Results

Baseline values are significant considerations, as analyses covary out baseline levels of response. In the following, systolic blood pressure, diastolic blood pressure, and heart rate are listed in that order. Baseline values were 116.90 (SD = 10.50), 62.69 (SD = 7.50), and 70.29 (SD = 12.50) for sons of EH parents; 109.22 (SD = 8.70), 72.75 (SD = 7.30), and 77.61 (SD = 25.40) for daughters of EH parents; 110.58 (SD = 9.20), 63.78 (SD = 5.80), and 80.13 (SD = 11.20) for sons of NT parents; and 107.14 (SD = 9.00), 63.94 (SD = 8.50), and 80.49 (SD = 7.30) for daughters of NT parents. Analyses indicated no significant differences between groups in baseline levels of systolic blood pressure and heart rate. A parental EH × sex interaction for diastolic blood pressure, $F(1, 45) = 4.96$, $p < .05$, showed that daughters of EH parents evidenced higher baseline diastolic blood pressure than other groups.

Further, since the main analyses utilize values with the baseline levels covaried out, in order to get a complete handle on "reactivity" it is important to note the actual levels and "real" amounts of change during the various conditions. Cardiovascular response was almost always greater in the various "stress contexts" (Anger 1 and 2; Digit Span 1 and 2; Mirror Tracing 1 and 2) than during the baseline. For sons of EH parents values *always* exceeded the baseline in these contexts; the range of responses in relation to baseline values were +3.02 to +13.41 for systolic blood pressure, +3.16 to +12.85 for diastolic blood pressure, and +5.19 to +14.02 for heart rate. For sons of NT parents, the ranges of response in comparison to the baseline were +.09 to +7.82 for systolic blood pressure, −2.36 to +6.05 for diastolic blood pressure, and −3.30 to +4.19 for heart rate (14 of 18 values exceeded the baseline). For daughters of EH parents, the ranges were −1.05 to +8.28 for systolic blood pressure, −2.92 to +6.25 for diastolic blood pressure, and +7.22 to +11.39 for heart rate (15 of 18 values exceeded the baseline). Finally, for daughters of NT parents the ranges were +2.53 to +13.11 for systolic blood pressure, +1.73 to +12.06 for diastolic blood pressure, and −.07 to +7.50 for heart rate (17 of 18 values exceeded the baseline). Thus, with only a few exceptions, "reactivity" to the conditions consisted of an elevation of response over baseline values.

Cardiovascular Reactions to Adults' Emotional Interactions

Systolic blood pressure.—The omnibus MANCOVA for this response yielded a significant parental EH status × sex × period interaction, $F(1, 44) = 4.55$, $p < .05$. Table 2 shows means adjusted for the baseline for each period as a function of parental EH status and sex. For the purposes of interpretation, it is again important to note that the means reflect the *relative* reactivity of children to conditions relative to baseline levels of response and are not necessarily indicative of differences in absolute levels of response.

Table 2 also shows the results of a priori simple interaction effects tests for parental EH status × sex for each period. Significant effects were found for the Friendly 1, Angry 1, Reconciliation 1, and Reconciliation 2 contrasts. Simple effects tests were conducted to follow up on these results further. For the Friendly 1 period, sons of EH parents and daughters of NT parents each reacted more than daughters of EH parents, $F(1, 23) = 7.45$, $p < .05$, and $F(1, 21) = 14.41$, $p < .001$, respectively. In the Angry 1

TABLE 2

SYSTOLIC BLOOD PRESSURE RESPONSES TO EMOTION CONDITIONS BY PARENTAL EH STATUS AND SEX OF CHILD

	Hypertensive Parent		Normotensive Parent		Parental EH Status by Sex of Child Contrast
Condition	Male	Female	Male	Female	$F(1, 44)$
Friendly 1	117.98 (10.73)	110.84 (8.35)	113.56 (23.37)	117.22 (10.59)	9.11**
Friendly 2	117.80 (10.98)	113.88 (8.99)	115.78 (24.16)	120.61 (12.97)	N.S.
Angry 1	117.94 (8.98)	109.44 (6.91)	110.94 (22.51)	113.72 (10.66)	12.63***
Angry 2	116.03 (7.91)	112.97 (15.42)	117.58 (25.66)	112.17 (10.66)	N.S.
Reconciliation 1	118.22 (11.37)	110.01 (6.16)	112.31 (23.32)	115.54 (12.64)	7.41**
Reconciliation 2	116.80 (8.54)	110.00 (30.50)	110.22 (23.66)	114.38 (11.42)	5.87*

NOTE.—All means are adjusted for baseline values. Numbers in parentheses are standard deviations. The numerals 1 and 2 refer to the first and second measures within each condition. Blood pressure is reported in mmHg.

* $p < .05$.

** $p < .01$.

** $p < .001$.

period, systolic blood pressure response was elevated for sons of EH parents in relation to daughters of EH parents, $F(1, 22) = 13.93$, $p < .001$, and sons of NT parents, $F(1, 22) = 10.20$, $p < .005$. For the Reconciliation 1 period, sons of EH parents and daughters of NT parents both responded more than daughters of EH parents, $F(1, 22) = 9.40$, $p < .005$, and $F(1, 21) = 5.36$, $p < .05$. Further, sons of EH parents showed a trend toward responding more than sons of NT parents, $F(1, 22) = 3.33$, $p < .10$. Finally, in the Reconciliation 2 period, sons of EH parents reacted more than daughters of EH parents, $F(1, 21) = 9.09$, $p < .01$, and showed a trend toward responding more than sons of NT parents, $F(1, 22) = 3.69$, $p = .06$.

Diastolic blood pressure.—The parental EH status × sex × condition × period interaction, $F(2, 42) = 4.60$, $p = .01$, was significant for the omnibus MANCOVA. Means adjusted for the averaged baseline for each period as a function of sex and parental EH status are presented in Table 3.

Table 3 also indicates the findings of tests of simple interaction effects for parental EH status × sex for each period. Significant results were found for the Friendly 1 and Angry 1 periods. Simple effects tests were conducted to examine these results further. For the Friendly 1 period sons of EH parents and daughters of NT parents were each more reactive than daughters of EH parents, $F(1, 22) = 11.92$, $p < .005$, and $F(1, 21) = 4.85$, $p < .05$, respectively. There were no significant simple effects contrasts for the Angry 1 period.

Heart rate.—In terms of the omnibus analysis, only the condition main effect was significant for heart rate, $F(2, 44) = 3.84$, $p < .025$, reflecting a general increase throughout the session in the reactivity of heart rate to the emotion conditions.

Cardiovascular Reactions to Laboratory Stressors

Analyses were conducted for systolic and diastolic blood pressure response and heart rate response to the digit span and mirror tracing conditions, but only the results for systolic blood pressure response were significant. For systolic blood pressure, there were significant parental EH status × sex interactions for both the digit span task, $F(1, 43) = 9.71$, $p < .005$, and mirror tracing task, $F(1, 43) = 6.87$, $p = .01$. Response to each task, adjusted for the baseline, as a function of parental EH status and sex is shown in Table 4.

Table 4 also shows the results of simple interactions effects tests of the parental EH status × sex interaction for each period. Significant effects were found for Digit Span 1, Digit Span 2, and Mirror Tracing 1. Simple effects tests showed that sons of EH parents had higher systolic blood pressure response than sons of NT parents during Digit Span 1 (forward digit span), $F(1, 22) = 7.43$, $p <$

TABLE 3

DIASTOLIC BLOOD PRESSURE RESPONSES TO EMOTION CONDITIONS BY PARENTAL EH STATUS AND SEX OF CHILD

	Hypertensive Parent		Normotensive Parent		Parental EH Status by Sex of Child Contrast
Condition	Male	Female	Male	Female	$F(1, 44)$
Friendly 1	69.86 (19.33)	62.16 (11.39)	65.81 (10.64)	68.26 (7.34)	5.82*
Friendly 2	66.49 (11.53)	69.77 (7.11)	64.27 (9.98)	66.03 (8.47)	N.S.
Angry 1	68.90 (6.62)	66.42 (8.35)	62.97 (10.35)	68.83 (9.07)	4.68*
Angry 2	67.64 (7.55)	65.53 (8.03)	68.68 (9.12)	66.99 (7.89)	N.S.
Reconciliation 1	65.80 (8.87)	67.95 (8.69)	63.89 (9.02)	66.06 (7.92)	N.S.
Reconciliation 2	64.48 (10.52)	66.82 (20.92)	62.02 (10.18)	70.59 (10.32)	N.S.

NOTE.—All means are adjusted for baseline values. Numbers in parentheses are standard deviations. The numerals 1 and 2 refer to the first and second measures within each condition. Blood pressure is reported in mmHg.
* $p < .05$.

TABLE 4

SYSTOLIC BLOOD PRESSURE RESPONSES TO CHALLENGE TASKS BY PARENTAL EH STATUS AND SEX OF CHILD

	Hypertensive Parent		Normotensive Parent		Parental EH Status by Sex of Child Contrast
Task Condition	Male	Female	Male	Female	$F(1, 43)$
Digit Span 1	124.00 (10.63)	118.70 (34.20)	118.34 (24.07)	123.70 (13.64)	6.54*
Digit Span 2	122.44 (37.19)	114.95 (33.67)	116.53 (23.82)	122.27 (13.64)	8.70**
Mirror Tracing 1	124.82 (12.77)	118.27 (9.10)	117.77 (25.54)	123.12 (11.93)	7.38**
Mirror Tracing 2	125.65 (36.13)	118.70 (9.49)	118.53 (25.27)	119.28 (10.89)	N.S.

NOTE.—All means are adjusted for baseline values. Numbers in parentheses are standard deviations. The numerals 1 and 2 refer to the first and second measures within each condition. Blood pressure is reported in mmHg.
* $p < .05$.
** $p < .01$.

.05, and also greater reactivity than sons of NT parents during Digit Span 2 (backward digit span), $F(1, 22) = 4.27$, $p = .05$. In addition, sons of EH parents evidenced greater systolic blood pressure responsivity than daughters of EH parents in the Mirror Tracing 1 task, $F(1, 23) = 4.30$, $p < .05$. None of the comparisons involving daughters of NT parents were statistically significant.

As the above analyses show, group differences were consistently found across stressors for systolic blood pressure. It was also of interest to determine whether these group differences reflected consistent individual differences in reactivity, that is, to examine whether individual patterns of response were consistent across stressors. To explore this notion, residual change scores were obtained, that is, scores with baseline values partialed out, and partial correlations across stressors were calculated.

Table 5 shows relations between responding to the periods of the angry interaction, digit span, and mirror tracing tasks for systolic blood pressure calculated separately for boys and girls. As the table shows, for boys systolic blood pressure reactivity was relatively consistent across stressors, including relations between responding to inter-adult anger and the challenge tasks. By contrast, there was far less evidence of consistency in relative reactivity among girls,

TABLE 5

PARTIAL CORRELATIONS OF RESPONDING ACROSS STRESS CONDITIONS FOR SYSTOLIC BLOOD PRESSURE

	Stress Condition					
Stress Condition	Angry 1	Angry 2	Digit Span 1	Digit Span 2	Mirror Tracing 1	Mirror Tracing 2
Angry 1	. . .	.18	.47*	.59**	.53**	.57**
Angry 2	.35	. . .	.34	.21	.18	.16
Digit Span 1	.29	.05	. . .	.67***	.49**	.35
Digit Span 2	.21	.13	.69***	. . .	.46*	.40
Mirror Tracing 1	.30	.13	.59**	.29	. . .	.77***
Mirror Tracing 2	.07	.25	.10	.11	.35	. . .

NOTE.—Values for boys are in the upper diagonal, and those for girls are in the lower diagonal. The numerals 1 and 2 refer to the first and second measure within each condition. Baseline values are partialled out in these calculations.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

and no significant relations between responding to anger and the challenge tasks. With regard to the last point, for heart rate six of eight partial correlations between the anger and challenge tasks were significant for boys, whereas none were significant for girls. For diastolic blood pressure, only one of eight partial correlations between anger and challenge tasks were significant for boys and girls, respectively. It should be emphasized that, since baseline levels were partialed out, these results reflect stability in the *reactivity* of response, not simply in the *level* of cardiovascular response, which would result if correlations without baseline values partialed out had been calculated.

Verbal-Report and Overt-Motor Responses to Adults' Emotional Interactions

Verbal report.—Analyses of variance with two between-subjects factors (parental EH status, sex) and one within-subject factor (emotion conditions) were conducted for each of the categories of children's negative emotional response to adults' emotional interactions. Children reacted with more anger, $F(2, 90) = 9.50$, $p < .001$, sadness, $F(2, 90) = 5.39$, $p < .01$, and fear, $F(2, 90) = 15.67$, $p < .001$, in response to the anger condition (M's = .82, .63, .88, respectively) than in response to the friendly (M's = .08, .18, .00, respectively) and reconciliation (M's = .00, .06, .12, respectively) conditions. However, there were no significant effects for the grouping variables.

Responding to interadult anger was thus not a function of history of hypertension within the family or sex of child. Another possibility was that history of marital conflict and distress, and overt maternal anger expression, predicted response. As already discussed, past research has found that children's response to interadult anger is a function of history of marital distress and of the characteristics of anger expression (e.g., Cummings & El-Sheikh, 1991). To explore this possibility, children were grouped according to (*a*) history of marital distress and (*b*) mother's report of her own overt anger expression in the home. Children were categorized as being from a distressed home if (*a*) either parent reported a MAT score of below 100 *or* (*b*) either parent reported the use of physical conflict tactics in marital disputes. Further, mothers were classified as relatively high versus low in terms of overt anger expression according to a median split on the AX/Out scale of the STAXI. Using these criteria, 12 families were classified as distressed/high overt maternal anger, 9 as distressed/low overt maternal anger, 13 as nondistressed/high overt maternal anger, and 14 as nondistressed/low overt maternal anger. It should be noted that parental EH and sex were statistically unrelated to MAT, PCT, and AX/Out scores for this sample.

An ANOVA with two between-subjects factors (marital distress, maternal anger) and one within-subject factor (emotion conditions) was conducted. A significant marital distress × overt maternal anger × condition interaction was found for children's report of feelings of anger, $F(2, 88) = 3.74$, $p < .05$. Children in the distressed/low overt maternal anger group verbalized the most anger in response to interadult anger ($M = 1.56$, SD = 2.35), followed by children in the nondistressed/high overt maternal anger ($M = .84$, SD = 1.46), nondistressed—low overt maternal anger ($M = .50$, SD = 1.16), and distressed/high overt maternal anger ($M = .25$, SD = .87) groups. Simple effects tests varying marital distress while holding maternal anger constant and varying maternal anger while holding marital distress constant, respectively, were nonsignificant. Post hoc tests comparing pairs of means indicated that children in the distressed/low overt maternal anger group verbalized significantly more anger than children in the distressed/high overt anger group, Tukey test, $p < .01$. A trend approached significance for the marital distress × condition interaction for children's report of feelings of fear, $F(2, 88) = 2.86$, $p = .06$. Children from maritally distressed homes reported more fear in response to interadult anger ($M = 1.19$, SD = 1.09) than children from nondistressed homes ($M = .56$, SD = 1.12).

Overt-motor responses.—An ANOVA with two between-subjects factors (hypertension status, sex) was conducted to examine relations between parental EH status and overt-motor behaviors during exposure to interadult anger. None of the effects were significant.

Consistent with the analysis plan just described, possible relations between family history of marital distress and overt maternal anger expression were then examined using ANOVAs with between-subjects factors of marital distress and overt maternal anger. A marital distress × overt maternal anger interaction was found for children's overall overt-motor reactivity to anger (sum of all overt-motor responses), $F(1, 38) = 3.86$, $p = .05$. Children in the distressed/low overt maternal anger group showed the greatest reactivity ($M = 2.75$, $SD = 1.67$), followed by children in the nondistressed/high overt maternal anger ($M = 2.33$, $SD = 1.87$), distressed/high overt maternal anger ($M = 2.14$, $SD = .90$), and nondistressed/low overt maternal anger ($M = 1.08$, $SD = .90$) groups. Simple effects tests were nonsignificant. Post hoc comparisons of pairs of means indicated that children in the distressed/low overt maternal anger group showed significantly greater overt-motor reactivity than children in the nondistressed/low overt maternal anger group, Tukey test, $p < .05$.

Next, following up on this result, analyses were conducted that examined verbal (verbal concern, verbal anger expression, mocking) and nonverbal (freezing, facial distress, postural distress, smiling, laughing) responses separately. A marital distress × overt maternal anger interaction was found for verbal response, $F(1, 38) = 5.98$, $p < .025$. As in the overall analysis, children in the distressed/low overt maternal anger group showed the greatest response ($M = .50$, $SD = .53$), followed by children in the nondistressed/high overt maternal anger ($M = .33$, $SD = .65$), nondistressed/low overt maternal anger ($M = .08$, $SD = .29$), and distressed/high maternal anger ($M = .00$, $SD = .00$) groups. Simple effects tests were nonsignificant. Post hoc comparisons of pairs of means indicated that children in the distressed/low overt maternal anger group engaged in significantly more of verbal behaviors indicative of concern and anger about adults fighting than children in the distressed/high maternal anger group, Tukey test, $p < .05$.

The analysis of nonverbal response yielded a main effect for marital distress, $F(1, 38) = 4.35$, $p < .05$, with children from distressed homes showing more nonverbal reactivity ($M = 2.20$, $SD = 1.01$) than children from nondistressed homes ($M = 1.50$, $SD = 1.14$). Thus, children's verbal and nonverbal reactivity to interadult anger varied as a function of different sets of family history variables.

Finally, these results raised questions about whether these family social history variables were associated with cardiovascular response to conditions. However, a series of analyses that substituted marital distress and overt maternal anger as grouping variables for parental EH status and sex, and otherwise followed the analysis plan for assessing cardiovascular response already described, revealed no statistically significant effects. Further, adding family social history variables to regression analyses that included terms for family history of EH did not improve prediction of cardiovascular response. Another series of analyses examined whether the interaction between family history of EH and marital distress/anger predicted overt-motor, verbal, or cardiovascular response. The inclusion of this multiplicative interaction did not improve prediction of cardiovascular response, nor did it improve prediction of overt-motor or verbal-reported response.

Discussion

These results suggest that heightened systolic blood pressure reactivity to some stressors may be found in sons of EH parents even before they are diagnosed to have EH disorders, that is, while they are in late childhood/early adolescence. However, a pattern of greater blood pressure reactivity was not found for daughters of EH parents, indicating that sex may be an important moderating variable in these relations.

A finding that sons of EH parents show greater cardiovascular reactivity to stress than other boys is consistent with other research (Holroyd & Gorkin, 1983; McCann & Matthews, 1988). However, other studies of differential responding to *social* stressors have yielded mixed results. Matthews et al. (1986) found no differences in cardiovascular reactivity as a function of parental history of EH in response to giving a classroom speech. But Holroyd and Gorkin (1983), who elicited anger from young adult males during a social interaction task, found that sons of EH parents reacted with greater heart rate, systolic blood pressure, and diastolic blood pressure than sons of NT parents. The fact that differences in response among sons of EH and NT parents were found when *anger* was the stimulus is consistent with the notion that anger may be a salient stimulus for evoking differential cardiovascular response in this population. On the other hand, greater systolic blood pressure reactivity was also found in response to the digit span task, suggesting that the disposition toward greater reactivity is not limited to situations involving anger but may emerge in multiple stress contexts.

However, daughters of EH parents did *not* show greater blood pressure reactivity than daughters of NT parents. In fact, in the conditions when comparisons were significant for blood pressure response (Friendly 1 and Reconciliation 1), greater response was found for daughters of NT parents than for daughters of EH parents, although none of the comparisons for the designated *stress* conditions (Anger, Mirror Tracing, Digit Span) were significant. Further, while reactivity in terms of blood pressure response was generally greater for sons of EH parents than for daughters of NT parents, means were quite close in several cases, and none of these comparisons were statistically significant. This is a surprising feature of the results. Among the groups, daughters of NT parents had the highest mean level of pubertal development whereas sons of EH parents had the lowest mean level, although these differences were not statistically significant. Differences in levels of pubertal development, whether menstruation occurs, and position in the menstrual cycle for females could be factors in comparisons of males and females and of within female groups and may also contribute to the relatively large standard deviations in cardiovascular response in some instances (see the tables; review in Saab, 1989). However, regarding the last point, it should be noted that standard deviations for actual levels within groups, as opposed to covariance-adjusted levels, were not quite so large (range = 7.22–16.22, median = 10.59). Relatedly, differences between males and females in cardiovascular and hormonal functioning beginning in adolescence and differences in at-risk status for EH suggest that same-sex comparisons are likely to be the most interpretable and appropriate for this age range.

The responses observed are, of course, not clinically significant in themselves and should not be interpreted as diagnostic of cardiovascular problems in adolescent sons of EH parents. The more relevant question is whether these patterns are *precursors* of later difficulties. Further, although mean differences in response to stressors were small, the conditions were specifically intended to induce only very mild stress in children. The fact that significant differences were observed at all with such mild stressors is noteworthy and argues for the practical relevance of the findings. Even greater differences in response might be observed given more powerful stimuli that are more directly relevant and threatening to the child, such as those the child might well encounter in everyday life. Further, the relatively small cell sizes reduced the statistical power to detect group differences and constitute a limitation of this study.

The findings lend support to the notion that boys' cardiovascular reactivity tends to be relatively stable across stressors, especially for systolic blood pressure and heart rate (e.g., Matthews et al., 1986, 1987). It would thus appear that patterns of cardiovascular reactivity to stress may be observed across multiple contexts among boys even by late childhood/early adolescence, which is an important issue to consider in models of environmental influences on cardiovascular reactivity.

However, family history of EH did *not* relate to verbal-report or overt-motor indicators of reactivity to adults' angry behavior. For these dimensions of response, indices of marital distress and overt maternal anger expression in the home were better predictors of children's responses. These findings are consistent with past research indicating that children are sensitized to anger, that is, come to evidence heightened behavioral and emotional response, as a result of repeated exposure to anger (e.g., J. S. Cummings et al., 1989; Cummings et al., 1985).

A twist was that mothers' relative *inhibition* of overt anger expression in homes characterized by marital distress was linked with heightened reactivity on some dimensions of response (report of angry feelings, behaviors indicative of anger, mocking and concern). One possible explanation is that children from distressed/low overt maternal anger homes have relatively high levels of negative feelings themselves due to the marital distress but also feel more comfortable expressing these feelings than children from distressed/high overt maternal anger homes because they are less concerned about becoming the victims of the mothers' anger. Notably, nonverbal reactivity by children, which is surely less likely to elicit anger from adults in conflict, was linked to marital distress, regardless of patterns of maternal anger expression. Alternatively, children from families with relatively high overt anger expression may have parents more likely to resolve their conflicts. Gottman and Krokoff (1989) report that while such a pattern is related to *concurrent* marital dissatisfaction, conflict and expression of anger are related to increased marital satisfaction in the long run, although there is some controversy in the literature about the interpretation of these data (see Gottman & Krokoff, 1990; Sher & Weiss, 1991; Smith, Vivian, & O'Leary, 1991; Woody & Costanzo, 1990). Further, recent research suggests that the resolution of anger greatly ameliorates children's distressed responding (E. M. Cummings et al., 1989, 1991) and that children are just as upset by nonverbal (nonovert) displays of anger as by verbal expressions of anger (Ballard & Cummings, 1990; E. M. Cummings et al., 1989). Children's responses to angry environments thus may depend not only on the level of marital distress but also on how parents handle their feelings of anger.

However, caution should be exercised in intepreting these findings. The study was not designed to focus primarily on this issue and consequently the criteria for marital distress and maternal anger were somewhat ad hoc due, in part, to the limited range of angry environments found in this sample. Relatedly, the fact that qualitative rather than quantitative criteria were used to classify marriages as distressed resulted in some loss of statistical power to detect effects (e.g., relations with cardiovascular responding). Further, father's anger was not assessed due to the noncooperation of most fathers. It is possible that family context has a greater impact on cardiovascular functioning than is apparent from this study. On the other hand, the findings do mesh with some recent work.

Taken together the results of this study suggest an intriguing notion: children's areas of risk or vulnerability in association with exposure to anger stimuli, and stress more generally, may be a function, in part, of their specific familial histories and backgrounds. Further, the pattern of outcomes illustrates the utility of a process-oriented approach to the study of familial factors that employs multiple measures, multiple contexts, and at-risk and normal samples, and adds to a process-oriented understanding of risk groups and response processes affected by exposure to others' anger and conflict. With regard to the familial transmission of EH, the identification of the *specific* family social environmental and individual child characteristics associated with increased cardiovascular reactivity in sons of EH parents is an important goal for future research.

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