

Do Behavioral Responses Mediate or Moderate the Relation Between Cardiovascular Reactivity to Stress and Parental History of Hypertension?

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To examine whether differences in behavioral responses to stress mediated or moderated the relation between cardiovascular response to stress and parental history of hypertension, 64 healthy undergraduates—16 men with hypertensive parents (PH+), 16 men without hypertensive parents (PH–), 16 PH+ women, and 16 PH– women—participated in a mental arithmetic task, mirror tracing task, and 2 interpersonal role plays. PH+ participants exhibited higher resting heart rates than PH– participants and higher resting systolic blood pressures (SBPs) than PH– women. PH+ participants exhibited greater SBP responses to tasks and engaged in more negative verbal and nonverbal behavior across tasks than PH– counterparts. Differences in behavioral responding neither mediated nor moderated the observed relation between parental history status and SBP response to stress.

Key words: cardiovascular reactivity, family history of hypertension, interpersonal stress, anger, behavioral responses to stress, heart rate, blood pressure

Many studies have examined the relation between parental history of hypertension and exaggerated cardiovascular reactivity to stress (see Muldoon, Terrell, Bunker, & Manuck, 1993). Although several investigators have reported exaggerated heart rate or blood pressure responses to mental stress among offspring of hypertensives (e.g., Jorgensen & Houston, 1981; Lamensdorf & Linden, 1992; Lawler & Allen, 1981; Miller & Ditto, 1991; Musante, Treiber, Strong, & Levy, 1990), others have failed to detect differences in cardiovascular response to stress among groups differing in hypertensive parentage (e.g., Manuck et al., 1996; Perini et al., 1990). One explanation for the mixed findings in this body of literature may be the failure of most of these investigators to examine concomitant covert (i.e., unobservable but inferred from self-report measures of cognition or affect) or overt (i.e., directly observable) behavioral responses that might serve as either mediators or moderators of the relation between family history of hypertension and cardiovascular response to mental stress. If persons with hypertensive parents exhibited different behavioral responses than those of normotensive parents (i.e., increased anger) and the behavioral responses were associated with the magnitude

of cardiovascular response, the extent to which differential cardiovascular responding would be observed between persons with and without hypertensive parents would depend on whether the behavioral response was elicited by the experimental task.

Only a few studies have measured potential mediating behavioral responses during these laboratory-based examinations of cardiovascular reactivity to stress (e.g., Ballard, Cummings, & Larkin, 1993; Ditto, 1986; Holroyd & Gorkin, 1983; Manuck, Proietti, Rader, & Polefrone, 1985; Miller & Sita, 1994; Semenchuk & Larkin, 1993). Although differences between persons with and without a parental history of hypertension have been observed for some covert behavioral responses, such as self-reported anger and anxiety (Manuck et al., 1985), and overt behavioral responses exhibited during a structured interpersonal task (Semenchuk & Larkin, 1993), this literature has lacked a programmatic focus. In designing these investigations, researchers have failed to build on previous findings, often using entirely different methods of assessment, making cross-study comparisons difficult. Furthermore, previous work of this type has not examined associations among these variables to determine whether behavioral differences observed among persons differing in hypertensive parentage mediated or moderated the relation between parental history of hypertension and cardiovascular response to stress.

The primary purpose of the current study was to examine behavioral responses that occurred during stressful mental activity that might help explain the commonly observed differences in cardiovascular reactivity to stress between young adults with (PH+) and without (PH–) a parental history of hypertension—that is, whether these behaviors operated as mediating or moderating variables for the relation between parental history status and cardiovascular reactivity to stress. According to Baron and Kenny (1986), mediation would occur in this instance if any behavioral variable explained the variance between parental history status and cardiovascular reactivity to stress. Moderation, in contrast, would

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be evident if a behavioral variable influenced the relation between parental history status and cardiovascular reactivity to stress but without explaining the shared variance. Specifically, this investigation examined the hypothesis that heightened cardiovascular reactivity to stress observed among PH+ participants, in contrast to their PH- counterparts, would be related to other covert or overt responses that occurred during the laboratory assessment of cardiovascular responding, and that these behavioral differences would help explain the commonly observed relation between parental history of hypertension and cardiovascular response to stress.

The specific covert and overt responses that were examined in this investigation included a constellation of self-reported measures of affect and observed behaviors that have been measured in previous investigations and have been shown to differ between PH+ and PH- persons; these included self-reported anger and anxiety as well as measures of both positive and negative verbal and nonverbal behaviors (Ditto, 1986; Lamensdorf & Linden, 1992; McCann & Matthews, 1988; Semenchuk & Larkin, 1993). Despite the promise of measuring observable behavioral responses during a structured task (Semenchuk & Larkin, 1993), this procedure has rarely been used in the literature and has never been attempted outside of interpersonal challenge situations. It is likely, however, that individual differences in overt behavioral responding exist, even when performing a noninterpersonal task (e.g., grimacing or swearing during a star tracer or mental arithmetic task). A. P. Shapiro (1961) noted that participants exhibited verbal responses during a Stroop Word Color Interference test that were unrelated to task performance; however, these data were not gathered or reported in a systematic fashion. The verbalizations observed by Shapiro included objections to the unfairness of the task and excuses for inadequate performance and may have influenced the magnitude of cardiovascular responding to stress. The current study systematically examined both measures of affect (e.g., anx-

iety and anger) and non-task-focused overt behavior (e.g., verbal and nonverbal behavior of participants) while participants engaged in both interpersonal and noninterpersonal tasks. In this regard, by selecting potential mediating variables that have been shown to distinguish PH+ and PH- participants in previous studies, the current study provides an initial step in developing a programmatic focus to this empirical question.

Method

Participants

Sixty-four healthy Caucasian undergraduates between the ages of 18 and 46 years ($M = 21.3$ years, $SD = 4.4$ years) were recruited for the study and received experimental credit in a psychology class for their voluntary participation. Sixteen men and 16 women reported a parental history of hypertension, and 32 individuals (16 men and 16 women) reported no parental history of hypertension. Parental history status was defined as PH+ if one or both parents reported a physician diagnosis of hypertension, not secondary to some other illness (e.g., coronary heart disease, diabetes), and as PH- if neither parent had received a physician diagnosis of hypertension but had their blood pressure measured within the past year. Telephone confirmation of blood pressure status, age, height, and weight for both parents was obtained by talking to at least one parent for all 64 participants.

Among the PH+ participants, 20 had a hypertensive father, 7 had a hypertensive mother, and 5 had two hypertensive parents. Independent sample t tests were conducted to compare differences between PH+ and PH- participants and their parents on age, height, weight, and body mass index (BMI; weight [in kilograms]/height [in squared meters]; see Table 1 for means and standard deviations). Results showed no significant group differences regarding age, height, and weight for both participants and their parents, although gender differences were observed for both height and weight ($ps < .001$).

Participants in the study were instructed to refrain from smoking, drinking caffeinated beverages, eating chocolate, and exercising for 3 hr before

Table 1
Means \pm Standard Deviations of Characteristics of Participants and Their Parents

Variable	PH+		PH-	
	Men	Women	Men	Women
Participants				
Age (years)	22.4 \pm 7.1	20.9 \pm 3.7	20.1 \pm 1.7	21.6 \pm 3.3
Height (in.)***	71.5 \pm 2.6	67.7 \pm 3.7	70.9 \pm 3.3	65.8 \pm 2.4
Weight (lb)***	169.8 \pm 16.0	149.3 \pm 22.1	176.3 \pm 23.2	134.4 \pm 20.9
BMI	23.5 \pm 2.4	23.4 \pm 2.8	24.8 \pm 3.7	22.0 \pm 4.4
Fathers				
Age (years)	45.8 \pm 2.1	47.9 \pm 4.0	46.0 \pm 4.5	45.6 \pm 2.6
Height (in.)	69.4 \pm 1.4	70.3 \pm 1.8	69.3 \pm 1.6	69.8 \pm 2.4
Weight (lb)	192.8 \pm 14.8	187.3 \pm 14.2	182.7 \pm 8.7	186.5 \pm 14.5
BMI	28.2 \pm 2.0	26.6 \pm 1.9	26.8 \pm 1.0	27.0 \pm 1.6
Mothers				
Age (years)	45.4 \pm 2.8	46.9 \pm 3.0	45.8 \pm 4.4	45.6 \pm 2.4
Height (in.)	63.9 \pm 2.8	65.7 \pm 3.2	64.4 \pm 2.8	64.3 \pm 2.9
Weight (lb)	149.2 \pm 16.3	149.6 \pm 22.5	141.4 \pm 16.2	146.3 \pm 9.3
BMI	25.9 \pm 3.8	24.4 \pm 4.1	24.2 \pm 3.9	25.1 \pm 2.7

Note. PH+ = participants with a positive parental history of hypertension; PH- = participants with a negative parental history of hypertension; BMI = body mass index.

*** $p < .001$ (men were significantly taller and heavier than women).

the experiment and to refrain from alcohol consumption for 12 hr before the experimental session, as recommended by D. Shapiro et al. (1996). Compliance with instructions was assessed with a self-report checklist administered before the laboratory session. Female participants were asked to report the date of their last menstrual period because some data have suggested a relation between cardiovascular reactivity to stress and menstrual cycle phase (Miller & Sita, 1994). Women were grouped into either preovulation phase or postovulation phase based on the menstrual cycle day reported during the laboratory session. Participants being tested between Day 0 (onset of menstruation) and Day 14 were classified as preovulation, and those being tested after Day 14 but before onset of the next menstruation were classified as postovulation. A chi-square analysis revealed no differences in menstrual phase between PH+ and PH- women at the time of testing, $\chi^2(1, N = 32) = 0.138, p = .71$. Seven PH+ women and 8 PH- women reported using oral contraceptives. Smokers and individuals using chewing tobacco were not excluded, but an equal number were included in each group: 6 PH+ men, 6 PH+ women, 6 PH- men, and 6 PH- women. By design, participants were excluded if they reported current use of medications or a chronic medical problem that affected cardiovascular activity. No participants, however, had to be excluded for these reasons.

Experimental Tasks

Mental Arithmetic Task

Participants were asked to subtract backward by 7s from the following three numbers: 500 (Minute 1), 613 (Minute 2), and 518 (Minute 3). Participants were instructed to state their answers aloud and work as quickly and accurately as possible. During the task, participants were given three standard prompts. The first prompt, "Try to do the best you can," was delivered after 30 s by the experimenter. The second prompt, "Try to be as accurate as possible," was delivered after 1 min, and the final prompt, "You need to try harder. You're making too many mistakes," was delivered after 2.5 min.

Mirror Tracing Task

This task involved tracing the outline of a six-point star using only its mirror image as a guide; a shield prevented individuals from looking directly at the star. Participants were instructed to trace the star as "quickly and accurately as possible" during a 3-min period. Three standard prompts were delivered throughout the task. The first prompt, "Try to work as quickly as possible," was delivered after 30 s. The second prompt, "Try to be as accurate as possible," was delivered after 1 min. The final prompt, "You need to work faster and not make as many mistakes," was delivered after 2.5 min.

Interpersonal Role-Plays

Two different 3-min role-plays (the "mess" scene and the "noise" scene) were presented to each participant in this study, one with a Caucasian male confederate and one with a Caucasian female confederate. Each role-play was based on a vignette containing a conflict situation, and participants were told that their goal was to reach a compromise with the confederate. The confederate was instructed not to reach a compromise. In the "mess" scene, participants were told, "Your roommate is a slob and the apartment is a mess. You always do your share. You ask him/her to do the dishes because you have a date/friends coming over. You get back home and the place is worse than when you left. Get your roommate to agree to clean up the apartment." In the "noise" scene, participants were told, "You've got to go to bed early tonight because you have a major test first thing in the morning. Your neighbor comes home and turns on the stereo full blast. Get

your neighbor to agree to turn off the stereo." Confederates were given a card containing a list of standardized prompts (e.g., "I didn't know you were home") to use for each of the two scenes. Confederates were introduced to each participant at the onset of each role-play as another student who was present to help with the role-play. In previous investigations using these conflict scenes, no significant differences between scenes on cardiovascular reactivity, behavioral responses, or order effects have been observed (Larkin, Semenchuk, Frazer, Suchday, & Taylor, 1998).

Cardiovascular Measures

Heart rate (HR) was detected using three surface electrodes attached to a Grass 7P3 preamplifier and Grass Model 7 polygraph (Quincy, MA). Two electrodes were placed on the right shoulder and one on the lower abdomen on the contralateral side of each participant. Blood pressure was measured using an IBS automated sphygmomanometer (Waltham, MA) that used an occluding cuff and microphone to detect Korotkoff sounds. The cuff was attached to the participant's nondominant arm with the microphone positioned over the brachial artery. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were digitally displayed and recorded by a research assistant. For purposes of this experiment, HR was measured continuously, and blood pressure was obtained during Minutes 1, 3, and 5 of the baseline periods and during Minutes 1 and 3 of each task period.

Self-Report Measures

Both the state subscales of the Spielberger Anger Expression Scale (STAXI) and the State-Trait Anxiety Inventory (STAI) were administered before and after each experimental task (Spielberger, 1988; Spielberger, Gorsuch, & Lushene, 1970). Both scales have demonstrated reliability and validity (Spielberger, 1988; Spielberger et al., 1970). Before each task, participants were instructed to respond to the items as they feel at that moment; however, after each task, they were asked to respond to the items according to how they felt during each task.

Behavioral Measures

Overt behavioral responses to each experimental task were videotaped using a JVC camcorder. These responses were coded using a modified version of the Marital Interaction Coding System (MICS; Hops, Mills, Patterson, & Weiss, 1972). First, nonverbal and verbal behaviors were scored using the MICS, a reliable method of measuring verbal and nonverbal behavior during social interactions (Filsinger, 1983). Individual codes were grouped into four major categories: positive verbal (accept responsibility, agree, approval, assent, compromise, positive solution, problem description, humor, normative), positive nonverbal (attention, laugh, positive physical contact), negative verbal (command, complain, disagree, negative solution, put-down, criticize, deny responsibility, excuse, interrupt, noncompliance), and negative nonverbal (not tracking and turn off) for purposes of analysis. Two research assistants were trained to code the behaviors during the four tasks to an 80% or better agreement criterion using a training tape. The raters viewed the tapes of each task, coding each behavioral response in 30-s segments. Interobserver agreement was calculated for 50% of the role-plays, which were coded by both observers. Interobserver agreement percentages were obtained by dividing the frequency of observer agreement in a category by the number of agreements plus disagreements. All categories that were observed exhibited satisfactory interrater agreement (i.e., greater than 82% agreement). Several categories were not observed by either coder during any scene by any participant, including excuse, approval, deny responsibility, noncompliant, normative, and positive physical contact. Therefore, these categories

were not used in analyses. The total number of words spoken during each task was also recorded and counted.

Procedure

Screening

Undergraduate volunteers were recruited at West Virginia University to attend a screening session. At this time, participants completed an approved consent form, the Family Medical History Questionnaire, and a brief screening questionnaire. Individuals were told that if they were eligible for participation they would be notified and scheduled to come back for a single laboratory session. Parental hypertension status was confirmed through a telephone conversation with at least one parent. Participants whose parental hypertensive status was confirmed were invited to participate in the laboratory phase of this experiment.

Laboratory Session

On arrival in the laboratory, all participants confirmed following the pre-session instructions regarding substance use and exercise. After completion of the self-report checklist, the blood pressure cuff and electrodes were attached, and individuals were instructed to rest for 20 min, the last 6 min serving as the first baseline. After baseline, participants reported their current levels of state anger and anxiety. The participant then engaged in the first task. After the first task, participants again rated their levels of state anger and anxiety according to how they felt while engaging in the task. The remainder of the procedure included presentation of the remaining three tasks interspersed by 6-min baseline periods. Baseline and task periods were always followed by completion of the State Anger and Anxiety subscales. The presentation of tasks was counterbalanced to control for the possibility of order effects. Four orders of task presentation used in this study were (a) mental arithmetic, male role-play, mirror tracing, female role-play, (b) male role-play, mental arithmetic, female role-play, mirror tracing, (c) mirror tracing, female role-play, mental arithmetic, male interaction, and (d) female role-play, mirror tracing, male-role play, mental arithmetic. After the final task, the equipment was detached and each participant was debriefed.

Design and Data Analysis

The experimental design was a $2 \times 2 \times 4$ mixed-factors design. There were two between-subject factors (group: PH+, PH-; and gender: man, woman) and one within-subject factor (task: mental arithmetic, mirror tracer task, interpersonal role-play with a male confederate, and interpersonal role-play with a female confederate). Congruent with the format for testing mediation and moderation established by Baron and Kenny (1986), the first set of analyses examined the association between family history of hypertension and both HR and blood pressure responses to stress. Consecutive measurements of HR, SBP, and DBP obtained during each 6-min baseline period and 3-min task period were averaged for each period. A Group \times Gender \times Task multivariate analysis of variance (MANOVA) was conducted on baseline cardiovascular variables, followed by a multivariate analysis of covariance (MANCOVA) for cardiovascular measures obtained during each task, covarying respective baseline values. The second set of analyses examined the relation between parental history of hypertension and all potential mediating or moderating variables using comparable MANOVAs (for behavioral variables) and MANCOVAs (for self-reported measures, covarying baseline measures of affect). Variables in which significant differences were observed between PH+ and PH- participants in the first two sets of analyses were entered into a series of regression analyses that tested for mediation and moderation effects, as outlined by Baron and Kenny.

Results

Cardiovascular Measures During Baseline Periods

The MANOVA on baseline cardiovascular variables revealed a main effect for gender, $F(3, 58) = 6.65, p < .001$, and group, $F(3, 58) = 7.99, p < .001$, and a Gender \times Group interaction, $F(3, 58) = 3.19, p < .04$.

HR

A follow-up univariate analysis of variance (ANOVA) revealed a significant main effect for group on baseline HR, $F(1, 60) = 9.65, p < .05$. Specifically, mean resting HRs were higher among PH+ participants ($M = 81.2$ beats per minute [bpm] ± 10.2) than PH- participants ($M = 73.5$ bpm ± 10.0).

SBP

The univariate ANOVA on SBP revealed a significant main effect for gender, $F(1, 60) = 15.23, p < .001$, and group, $F(1, 60) = 12.27, p < .001$. A Group \times Gender interaction on baseline SBP was also observed, $F(1, 60) = 9.03, p < .01$. Analysis of simple effects using F tests revealed that the mean baseline SBP for PH+ men ($M = 125.1$ mm Hg ± 8.7) and PH+ women ($M = 123.4$ mm Hg ± 3.9) was significantly higher than for PH- women ($M = 110.9$ mm Hg ± 6.6) but not PH- men ($M = 124.1$ mm Hg $\pm 10.0, ps < .05$).

DBP

The univariate ANOVA revealed no main effects or interactions for baseline DBP.

Cardiovascular Responses During Task Performance Periods

The MANCOVA revealed main effects for gender, $F(3, 55) = 5.64, p < .01$; group, $F(3, 55) = 5.35, p < .01$; and task, $F(9, 426) = 4.78, p < .001$. Covariance-adjusted means for PH+ and PH- groups are displayed in Figure 1.

HR Response

A follow-up analysis of covariance (ANCOVA) revealed a significant main effect for task on HR response, $F(3, 179) = 7.71, p < .001$. Mean comparisons using the Tukey test revealed that the adjusted mean HR response to the female role-play ($M = 87.5$ bpm ± 10.3), male role-play ($M = 86.3$ bpm ± 10.4), and the mental arithmetic task ($M = 88.3$ bpm ± 11.3) were all greater than the adjusted mean HR response to the mirror tracing task ($M = 82.4$ bpm $\pm 10.9, ps < .01$).

SBP Response

Main effects for gender, $F(1, 59) = 4.55, p < .05$; group, $F(1, 59) = 14.05, p < .001$; and task, $F(3, 179) = 8.34, p < .001$, were observed for SBP response. Men participants exhibited a greater adjusted mean SBP response ($M = 139.4$ mm Hg ± 8.2) to all tasks than women participants ($M = 132.8$ mm Hg ± 7.3). Also,

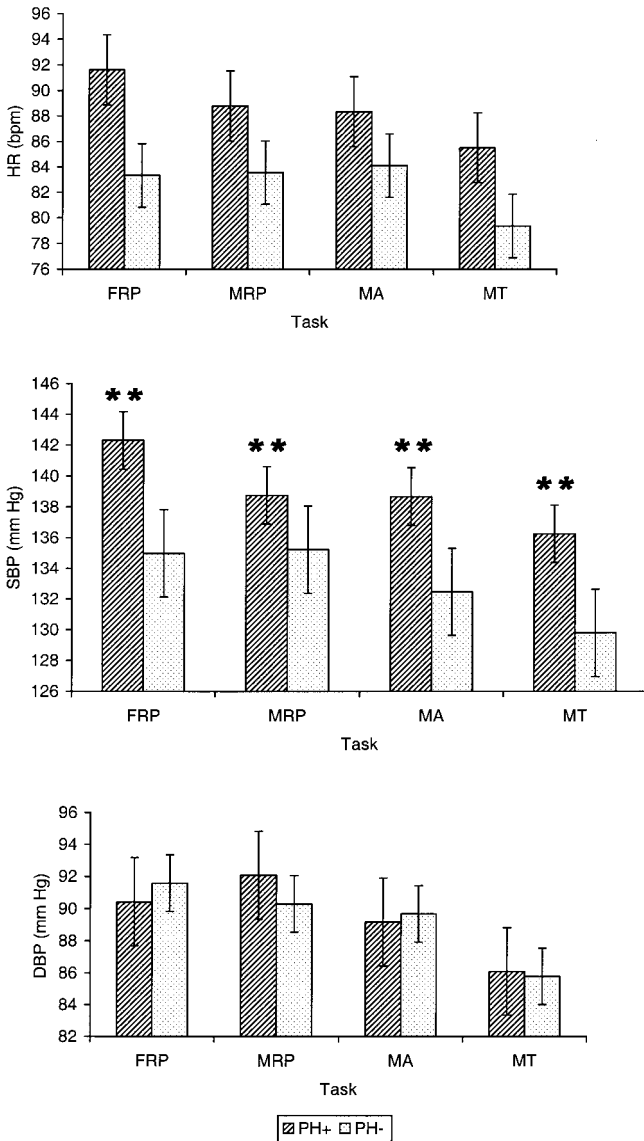


Figure 1. Adjusted mean (and standard error) heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) for PH+ and PH- participants during the female role-play (FRP), male role-play (MRP), mental arithmetic (MA), and mirror tracing (MT) tasks. bpm = beats per minute; PH+ = participants with a positive parental history of hypertension; PH- = participants with a negative parental history of hypertension. ** $p < .01$.

PH+ participants exhibited greater adjusted mean SBP response to all tasks ($M = 139.0$ mm Hg ± 5.9) than PH- participants ($M = 133.1$ mm Hg ± 9.5). A Tukey test revealed that the adjusted mean SBP response to the female role-play ($M = 138.6$ mm Hg ± 9.9) was significantly higher than the adjusted mean SBP response to the mirror tracing task ($M = 133.0$ mm Hg ± 10.4 , $p < .01$).

DBP Response

A main effect for gender, $F(1, 59) = 13.71$, $p < .001$, was observed on DBP response. Adjusted mean DBP responses were

higher among male ($M = 94.8$ mm Hg ± 15.5) than female ($M = 84.1$ mm Hg ± 9.2) participants.

Analyses of Potential Mediators and Moderators

Covert Behavioral Responses

The MANCOVA revealed a significant main effect for task, $F(6, 354) = 6.60$, $p < .001$. The adjusted mean responses are displayed in Table 2.

Self-Reported Anger

A univariate ANCOVA revealed a main effect for task, $F(3, 179) = 5.21$, $p < .01$. Mean comparisons using the Tukey test revealed that the adjusted mean STAXI scores were higher during the female role-play than the mental arithmetic task ($p < .01$).

Self-Reported Anxiety

A main effect for task, $F(3, 179) = 3.46$, $p < .05$, was also observed for self-reported anxiety. The Tukey test revealed that the adjusted mean STAI scores were higher in response to the mental arithmetic task than the mirror tracing task, female role-play, and male role-play task ($ps < .05$).

Overt Behavioral Responses

Rate of Speech

To assess differences in the rate of speech, the total number of words spoken by participants was counted for each task. The ANOVA conducted on the number of words spoken revealed a main effect for task, $F(1, 60) = 777.37$, $p < .001$. No other significant main effects or interactions were observed. As would be expected given the nature of the tasks (e.g., interpersonal vs. noninterpersonal), the Tukey test revealed that a significantly greater number of words were spoken during both the male role-play ($M = 337.5 \pm 89.0$) and female role-play tasks ($M = 324.2 \pm 80.9$) than during both the mental arithmetic task ($M = 4.7 \pm 13.2$) and the mirror tracing task ($M = 10.0 \pm 13.9$, $ps < .01$).

Behavioral Parameters

The MANOVA conducted on the overt behavioral parameters from the MICS (negative verbal responses, negative nonverbal responses, positive nonverbal responses, and positive verbal responses) revealed a significant main effect for group, $F(4, 57) = 3.45$, $p < .05$, and task, $F(12, 469) = 152.5$, $p < .05$, as well as a Group \times Task interaction, $F(12, 469) = 1.98$, $p < .05$. Mean responses are displayed in Table 3.

Positive verbal behavior. A significant main effect for task, $F(3, 180) = 658.33$, $p < .001$, was observed for positive verbal behavior. Mean comparisons using the Tukey test revealed that a greater number of positive verbal statements were exhibited during the female role-play and male role-play tasks in contrast to both the mental arithmetic task and mirror tracer task ($ps < .01$).

Table 2
Adjusted Mean ± Standard Deviations for STAI and STAXI Scores by Task

Variable	FRP	MRP	MA	MT	All tasks
STAXI					
PH+	17.06 ± 0.99	17.07 ± 0.66	14.68 ± 3.12	14.95 ± 0.55	15.94 ± 1.17
PH-	17.46 ± 2.65	16.93 ± 0.27	14.59 ± 2.53	15.38 ± 1.93	16.09 ± 1.63
All**	17.26 ± 1.99	16.99 ± 0.51	14.63 ± 2.81	15.17 ± 1.43	16.01 ± 1.41
STAI					
PH+	45.83 ± 8.12	45.81 ± 8.24	48.86 ± 7.66	46.58 ± 8.97	46.77 ± 7.73
PH-	44.27 ± 8.20	43.24 ± 6.80	47.22 ± 6.97	43.77 ± 7.29	44.63 ± 6.70
All*	45.05 ± 8.13	44.53 ± 7.60	48.04 ± 7.31	45.17 ± 8.23	45.70 ± 7.26

Note. STAI = State-Trait Anxiety Inventory; STAXI = Spielberger Anger Expression Scale; FRP = female role-play; MRP = male role-play; MA = mental arithmetic task; MT = mirror tracing task; PH+ = participants with a positive parental history of hypertension; PH- = participants with a negative parental history of hypertension.

* $p < .05$ (mean State Anxiety subscale scores were significantly higher during the MA task than the FRP, MRP, and MT tasks). ** $p < .01$ (mean State Anger subscale scores were significantly higher during the FRP task than the MA task).

Positive nonverbal behavior. A significant main effect for task, $F(3, 180) = 6.97, p < .001$, was observed for positive nonverbal behavior. The Tukey test revealed that a greater number of positive nonverbal responses were exhibited during the female role-play and male role-play task in contrast to the mirror tracer task ($ps < .01$).

Negative verbal behavior. Significant main effects for task, $F(3, 180) = 39.31, p < .001$, and group, $F(1, 60) = 7.48, p < .01$, were observed for negative verbal behavior. PH+ participants

used more negative verbal responses than PH- participants. Follow-up ANOVAs for each individual code comprising this category revealed significant group main effects for ratings of both disagree, $F(1, 62) = 4.04, p < .05$, and put-down, $F(1, 60) = 7.15, p < .01$. Regarding these effects, PH+ participants engaged in more disagreeing statements and put-downs than their PH- counterparts. Regarding the main effect for task, analysis of mean comparisons revealed that a greater number of negative verbal responses were exhibited during the female role-play and male

Table 3
Mean ± Standard Deviations of Overt Behavioral Responses by Task

Variable	FRP	MRP	MA	MT	All tasks
Positive verbal					
PH+	30.78 ± 9.77	34.50 ± 7.67	0.94 ± 1.13	0.56 ± 1.27	16.70 ± 3.57
PH-	34.41 ± 9.95	32.59 ± 8.45	0.72 ± 1.08	0.44 ± 0.76	17.04 ± 4.40
All***	32.59 ± 9.95	33.55 ± 8.07	0.83 ± 1.12	0.50 ± 1.04	16.87 ± 3.98
Positive nonverbal					
PH+	3.50 ± 4.44	3.41 ± 3.53	2.66 ± 3.21	1.91 ± 2.10	2.87 ± 2.44
PH-	3.72 ± 3.78	3.93 ± 3.66	2.03 ± 2.06	2.38 ± 2.43	3.02 ± 2.50
All ^b ***	3.61 ± 4.09	3.67 ± 3.58	2.34 ± 2.69	2.14 ± 2.27	2.94 ± 2.45
Negative verbal					
PH+	7.78 ± 9.16	7.06 ± 4.51	0.72 ± 1.67	0.50 ± 1.50	4.02 ± 2.67
PH-	5.38 ± 5.17	4.34 ± 2.98	0.16 ± 0.37	0.09 ± 0.30	2.49 ± 1.58
All ^c ***	6.58 ± 7.48	5.70 ± 4.03	0.44 ± 1.23	0.30 ± 1.09	3.25 ± 2.30
Negative nonverbal					
PH+	1.69 ± 2.65	2.06 ± 4.13	0.84 ± 3.08	0.66 ± 1.04	1.31 ± 1.58
PH-	0.78 ± 1.75	0.94 ± 1.39	0.47 ± 0.80	0.28 ± 0.58	0.61 ± 0.65
All ^e *	1.23 ± 2.27	1.50 ± 3.11	0.66 ± 2.24	0.47 ± 0.85	0.96 ± 1.25

Note. FRP = female role-play; MRP = male role-play; MA = mental arithmetic task; MT = mirror tracing task; PH+ = participants with a positive parental history of hypertension; PH- = participants with a negative parental history of hypertension.

^a Mean number of positive verbal responses was significantly greater during FRP and MRP tasks than MA and MT tasks. ^b Mean number of positive nonverbal responses was significantly greater during FRP and MRP tasks than MT tasks. ^c Mean number of negative verbal responses was significantly greater during FRP and MRP tasks than MA and MT tasks. ^d Mean number of negative verbal responses was significantly greater among PH+ participants than PH- participants. ^e Mean number of negative nonverbal responses was significantly greater during the MRP task than the MT task. ^f Mean number of negative nonverbal responses was significantly greater among PH+ participants than PH- participants.

* $p < .05$. ** $p < .01$. *** $p < .001$.

role-play tasks in contrast to both the mental arithmetic task and mirror tracer task ($ps < .01$).

Negative nonverbal behavior. Significant main effects for task, $F(3, 180) = 3.11, p < .05$, and group, $F(1, 60) = 5.12, p < .05$, were observed for negative nonverbal behavior. PH+ participants used more negative nonverbal responses than PH- participants. Follow-up analyses on individual codes comprising this category revealed a significant main effect only for turn off, $F(1, 62) = 6.11, p < .05$. PH+ participants engaged in more rolling of their eyes and sighing than their PH- counterparts. Regarding the main effect for task, the Tukey test revealed that a greater number of negative nonverbal responses were exhibited during the male role-play than during the mirror tracing task ($p < .01$).

Task Performance

Because performance on the noninterpersonal tasks was quantifiable, performance was also measured and analyzed using Group \times Gender ANOVAs. For the mental arithmetic task, two performance scores were calculated: the number of subtractions attempted and the number of correct subtractions. For the mirror tracer task, two performance scores were also calculated: the number of stars completed and the number of errors. No significant main effects or interaction effects on performance for either task were observed.

Examination of Mediating and Moderating Variables Explaining the Relation Between Parental History of Hypertension and Cardiovascular Reactivity to Mental Stress

Given the requirement that a relation must be present between the independent and dependent variables to assess mediation, the only relation in which this condition was met was that between PH status and SBP responses to the tasks. Likewise, given that a relation must be present between the independent variable and the mediator, only two potential mediators were identified in this study: negative verbal behavior and negative nonverbal behavior.

Mediation and Moderation of the Relation Between PH Status and SBP Response to Stress by Negative Verbal Responses

The relation between PH status and SBP responses was examined to assess whether negative verbal behavior exhibited during the tasks as measured through the MICS may have mediated or moderated the relation. Mediator effects were assessed using a series of three regression analyses (see Figure 2). In the first regression, negative verbal behavior was regressed on parental history status, $R^2 = .11, F(1, 62) = 7.18, p < .01$. In the second regression, adjusted SBP response was regressed on parental history status, $R^2 = .12, F(1, 62) = 8.81, p < .01$. In the third regression, adjusted SBP response was regressed on both parental history status and negative verbal behavior, $R^2 = .13, F(2, 61) = 4.39, p < .05 (\Delta R^2 = .01, ns)$. Because a relation was not observed between negative verbal responses and adjusted SBP response in the third regression ($\beta = -.04$), negative verbal

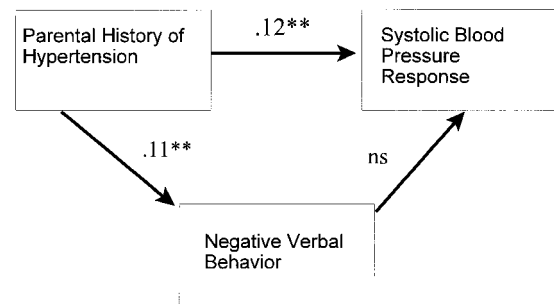


Figure 2. Relations determined using regression analyses among negative verbal responses, parental history status, and systolic blood pressure response to stress. ** $p < .01$.

behaviors did not emerge as a mediator of the relation between PH status and SBP reactivity to stress.

A hierarchical regression was used to examine the moderating effects of negative verbal responses. According to Baron and Kenny (1986), a variable can serve as a moderator if a significant regression coefficient is seen for the product of parental history status and negative verbal behavior after the step in which both individual variables are entered into the regression equation. A significant correlation coefficient was not observed for the product of parental history status and negative verbal behavior. Therefore, negative verbal behavior served as neither mediator nor moderator of the relation between PH status and SBP response to stress.

Mediation and Moderation of the Relation Between PH Status and SBP Response to Stress by Negative Nonverbal Responses

The relation between PH status and SBP responses was examined to assess whether negative nonverbal responses measured via the MICS exhibited during the tasks may have mediated or moderated the relation (see Figure 3). Mediator effects were assessed as previously described. In the first regression, negative nonverbal behavior was regressed on parental history status, $R^2 = .08, F(1, 62) = 5.28, p < .03$. In the second regression, adjusted SBP response was regressed on parental history status, $R^2 = .12, F(1, 62) = 8.81, p < .01$. In the third regression, adjusted SBP response was regressed on both parental history status and negative nonverbal behavior, $R^2 = .12, F(2, 61) = 2.92, p < .05 (\Delta R^2 = .00, ns)$. Because a significant relation was not observed between negative nonverbal responses and adjusted SBP response in the third regression ($\beta = -.01$), negative nonverbal behaviors did not emerge as a mediator of the relation between PH status and SBP reactivity.

A hierarchical regression was used to examine the moderating effects of negative nonverbal responses. A significant correlation coefficient was not observed for the product of parental history status and negative nonverbal behavior. Therefore, negative nonverbal behavior served as neither mediator nor moderator of the relation between PH status and SBP response to stress.

Discussion

The primary purpose of this study was to determine whether the relation between parental history of hypertension and cardiovas-

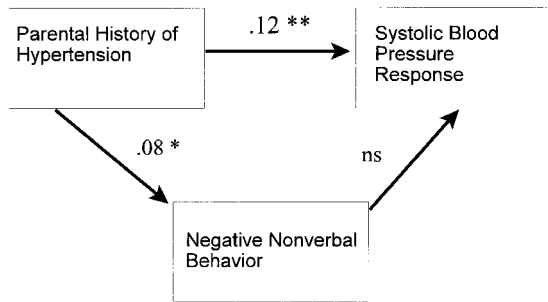


Figure 3. Relations determined using regression analyses among negative nonverbal responses, parental history status, and systolic blood pressure response to stress. * $p < .05$. ** $p < .01$.

cular reactivity to stress was mediated or moderated by any of the overt or covert behavioral variables that were assessed. Of the two variables that met the criteria for analysis (i.e., negative verbal behavior, negative nonverbal behavior), neither was found to mediate or moderate the relation between parental history of hypertension and SBP reactivity. This is in contrast to the findings of Frederikson, Robson, and Ljungdell (1991), who found that PH+ participants had higher resting ambulatory blood pressure measures than PH- during waking hours, but not during sleep, which suggested potential behavioral mediation or moderation of cardiovascular reactivity to stress. However, the findings from the current study were similar to those observed by Semenchuk and Larkin (1993), suggesting that offspring of hypertensive parents exhibited two types of orthogonal responses: one physiological and the other behavioral. Some PH+ individuals may respond to laboratory stressors primarily through overt behavioral responses, and others may respond physiologically. Obviously, additional research is required to explore whether the exaggerated cardiovascular response to stress and the proclivity toward negative behavioral responses constitute comparable risk factors for essential hypertension or heart disease.

It is clear that additional information about the nature of the family environment in hypertensive households would be helpful to examine the types of interpersonal dilemmas that children in these families experience on a regular basis. Associations between family arguments and cardiovascular responding have been evidenced in couples with a parental history of hypertension (Ewart, Taylor, Kraemer, & Agras, 1991), which suggests that, for offspring of hypertensive parents, certain behavioral styles of interacting in relationships might predispose them to essential hypertension or cardiovascular disease. Woodall and Matthews (1989) found that boys who were raised in authoritarian families with low levels of positive affiliation exhibited higher HR responses than boys from less authoritarian families. These findings were later corroborated by Wright et al. (1993), who found similar measures of control and conflict within the family to be related to hemodynamic responses to stress. The potential exists for a cyclical pattern of conflict avoidance or inadequate expression of feelings to develop from generation to generation in hypertensive families. It has yet to be determined what risk for disease might be associated with these behavioral response patterns.

Semenchuk and Larkin (1993) suggested that early interventions might be focused toward high-risk families (e.g., positive parental

history of hypertension) using a skills-based approach of conflict management and perhaps including relaxation training, assertiveness training, and social skills training. Turner (1994) suggested the use of a risk identification protocol to further understand the reactivity hypothesis as well as other biopsychosocial factors associated with cardiovascular disease risk. This assessment protocol included information regarding a patient's exercise habits, dietary habits, parental hypertensive status, covert parameters (e.g., self-reported anger and anxiety), physical characteristics (e.g., BMI), and environmental factors (e.g., social support, frequency of daily stress). Although considerable evidence has accumulated suggesting that such a risk profile could be derived early in life, Turner did not include overt negative behavioral responses among the variables he chose to include in his risk identification protocol. Based on the current findings, coupled with those of previous investigations (Baer et al., 1983; Baer, Vincent, Williams, Bourianoff, & Bartlett, 1980; Semenchuk & Larkin, 1993), it could be argued that the long-term follow-up studies on individuals using the risk identification protocol to examine relations between different overt and covert parameters and disease end points that Turner recommends should also include measures of negative behavioral responses to interpersonal conflict. Given the findings of the current study, with regard to different subgroups of offspring of hypertensive parents, information obtained through such a risk identification protocol may lead to more appropriate clinical interventions with high-risk individuals (e.g., offspring of hypertensive parents).

This study also provided evidence that offspring of hypertensive parents responded differently than those of normotensive parents with regard to both cardiovascular and behavioral responses to laboratory stress of both an interpersonal and noninterpersonal nature. Both male and female PH+ participants exhibited greater SBP responses to the tasks and engaged in more negative verbal and negative nonverbal behavior than their PH- counterparts.

With regard to differences in cardiovascular parameters, higher resting HR and SBP were observed in both male and female PH+ participants. Previous studies using male participants also have found higher resting HRs among PH+ participants (Holroyd & Gorkin, 1983; Semenchuk & Larkin, 1993). Lawler, Lacy, Armstead, and Lawler (1991) found PH+ men to have higher resting SBP than their PH- counterparts as well but did not find the same among women. Other studies, however, have not observed differences in baseline cardiovascular measures (e.g., Polefrone & Manuck, 1988). It is possible that these inconsistent findings pertaining to baseline cardiovascular levels among PH+ and PH- participants may be related to some unmeasured cognitive or affective parameter that occurs while the participant waits during initial and intervening rest periods. For example, some participants may tolerate the relatively quiet rest period better than others.

Consistent with many previous investigations, PH+ participants exhibited greater SBP responses to the laboratory tasks than PH- participants (e.g., Ballard, et al., 1993; Ditto, 1986; Holroyd & Gorkin, 1983; Johnson, 1989; Manuck & Proietti, 1982; Semenchuk & Larkin, 1993). Additionally, men exhibited greater SBP and DBP responses than women, a finding consistent with some previous studies (e.g., Matthews, Davis, Stoney, Owens, & Caggiola, 1991).

In the current study, assessment of covert behavioral responses to the laboratory tasks did not reveal differences in self-reported

anger or self-reported anxiety between participants with and without a parental history of hypertension. Although previous investigations have reported differences in either self-reported anger or anxiety between PH+ and PH- participants (Manuck et al., 1985), these findings have been inconsistently observed in the literature. As stated previously, however, the responses have not typically been "featured" in these investigations; therefore, the studies have largely not been designed with eliciting the response under study (e.g., self-reported anxiety) in mind.

Examination of the findings regarding differences in PH+ and PH- participants in overt behavioral response was more promising. Consistent with previous studies (Baer, et al., 1980, 1983; Semenchuk & Larkin, 1993), PH+ participants exhibited more negative nonverbal responses than PH- participants. Examination of the individual codes revealed that PH+ participants exhibited more rolling of their eyes and sighing than PH- participants, a finding also consistent with results of Semenchuk and Larkin. Negative nonverbal behaviors frequently displayed among offspring of hypertensives, specifically gaze aversion or "not tracking," identified by Baer and colleagues in several studies, have been hypothesized to represent a form of conflict avoidance used in hypertensive households (Gentry, Chesney, Gary, Hall, & Harburg, 1982). In addition, PH+ participants exhibited more negative verbal behavior than their PH- counterparts, which consisted of engaging in more disagreeing statements and put-downs of the confederate. These findings are consistent with results of Morrison, Bellack, and Manuck (1985), who found that aggressive responding during a role-play scenario was related to hypertension.

Conclusions

The current study yielded important information regarding the heterogeneous nature of offspring of hypertensive parents. Although PH+ participants demonstrated exaggerated cardiovascular responding and a greater frequency of negative verbal and nonverbal behaviors compared with PH- participants, these differences were independent. That is, those PH+ participants demonstrating exaggerated cardiovascular responses were not the same individuals demonstrating a greater frequency of negative verbal and nonverbal behaviors. These findings echo some interesting questions raised in earlier investigations (e.g., Baer et al., 1980, 1983; Semenchuk & Larkin, 1993) about the potential behavioral mechanisms through which offspring of hypertensives may be at risk for cardiovascular disease. As suggested by previous researchers (Ewart et al., 1991; Semenchuk & Larkin, 1993), it is possible that the risk for cardiovascular disease in offspring of hypertensive patients involves not only an exaggerated reactivity to stressors but a learned maladaptive behavioral response to stressors. Therefore, determining the risk for cardiovascular disease among offspring of hypertensive patients may require assessing behavioral responses to stress in addition to assessing cardiovascular responses to stressors. Future research examining behavioral and cardiovascular responses to stress and the development of cardiovascular diseases is needed among offspring of hypertensive parents to allow researchers to determine which factors are most important for developing prevention programs for persons of hypertensive parentage.

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