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Cardiovascular reactivity of Singaporean male police officers as a function of task, ethnicity and hostility

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Abstract

Objective: This research examined hemodynamic processes in cardiovascular reactivity (CVR) as a function of task, ethnicity and trait hostility. *Method:* One hundred and fourteen male patrol officers from the Singapore Police Force participated in this experimental study. Trait hostility was measured using the interpersonal hostility assessment technique to derive a hostile behavior index (HBI). Heart rate, blood pressure and hemodynamic measures were taken while participants performed three tasks: mental arithmetic, number reading and anger recall (AR). *Results:* AR elicited the greatest blood pressure, vascular and cardiac output reactivity. HBI scores were positively related to systolic blood pressure reactivity during AR for Malays whereas this was not true for Indians and Chinese. Across tasks Indians with high HBI scores appeared to be cardiac reactors whereas the reactivity patterns for Malays and Chinese were undifferentiated. Self-report of negative mood was not related to CVR. *Conclusion:* These results are consistent with the higher rates of coronary heart disease deaths among Indians as well as the higher rates for hypertension among Malays in Singapore.

Keywords: Ethnicity; Hostility; Impedance cardiography; Hemodynamic processes; Singapore; Anger; Cardiovascular reactivity

1. Introduction

Over the past few decades empirical evidence has accumulated supporting the importance of anger/hostility as a risk factor in coronary heart disease (CHD) (Barefoot et al., 1983, 1989; Shekelle et al., 1983). A recent meta-analysis has shown that the hostility–CHD relationship is a reliable one that remains strong even after traditional CHD risk factors have been controlled for (Miller et al., 1996).

Abbreviations: AR, anger recall; BMI, body mass index; BSA, body surface area; CHD, coronary heart disease; CVR, cardiovascular reactivity; IHAT, interpersonal hostility assessment technique; HBI, hostile behavior index; MA, mental arithmetic; NR, number reading; SI, structured interview; S.D., standard deviation; S.E., standard error.

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Several hypotheses have been suggested to explain this relationship (Smith, 1992) of which one of the best supported is the cardiovascular reactivity (CVR) model which argues that individuals high in hostility tend to show exaggerated psychophysiological, and particularly cardiovascular, reactivity to certain types of stressful situations. Evidence suggests that individuals high in hostility tend to show high levels of CVR when harassed, engaged in debate or when asked to recall anger-provoking events (Everson et al., 1995; Suarez et al., 1998; Suarez and Williams, 1989; Suls and Wan, 1993). This greater CVR is then hypothesized to increase CHD risk by exacerbating the process of atherosclerosis. This is hypothesized to occur because exaggerated CVR increases the risk of injury to the tunica intima, thereby increasing the rate of build-up of atherosclerotic plaques (Kamarck et al., 1998; Williams, 1994).

Although the relationship between hostility and CVR is now well established questions remain about the generalisability of these findings. The vast majority of studies have been done in North America and Europe and with predominantly Caucasian populations (Everson et al., 1995; Suarez et al., 1998; Suarez and Williams, 1989) although a number studies have been done with African Americans (Ernst et al., 1997; Fang and Myers, 2001). Very few studies have been done with Asian populations and there is reason to believe that there may be ethnic differences in the relationship of anger/hostility to CVR. A recent study by Bishop and Robinson (2000) in Singapore found differences between Chinese and Indian males in their CVR patterns. Similar to findings in North America, Chinese males high in dispositional anger showed heightened CVR to being harassed whereas this was not true for those low in dispositional anger. Among Indians, however, heightened CVR to harassment was obtained for participants low in dispositional anger and those high in dispositional anger showed high levels of CVR even when not harassed. These results were interpreted as being consistent with the fact that Indians have been found to have a consistently high risk of developing CHD (Hughes et al., 1990). From 1991 to 1998, Indian males in Singapore had an average heart disease mortality rate that was 1.81 times higher than Malay males and 2.69 times higher than Chinese males. Malay males had an average hypertension mortality rate that was 1.56 times higher than the Chinese males and 1.44 times higher than the Indian males (Registry of Births and Deaths, 1991).

Although the results from the study by Bishop and Robinson (2000) are intriguing they also leave a number of questions unanswered. In particular, this study included only blood pressure and heart rate and provided no information about the underlying hemodynamics involved. Blood pressure changes may be due to changes in cardiac output, peripheral resistance or both (Sherwood and Turner, 1992). An investigation of the underlying hemodynamic processes would help identify the sources of blood pressure changes among the ethnic groups in Singapore. There is also evidence that individuals have hemodynamic 'traits' (reactivity traits) that have test–retest reliability and are also consistent across tasks (Kasprowicz et al., 1990). Although current research on the relationship between specific reactivity traits and specific cardiovascular disease risk is still preliminary and both hypertension and CHD are subclasses of cardiovascular disease, there is also some evidence to suggest that these hemodynamic patterns are differentially associated with cardiovascular disease. Some studies have suggested that individuals who are at risk of developing hypertension tend to be vascular reactors (Lovallo and al'Absi, 1998) whereas there is other evidence that cardiac reactivity may be related to CHD (Sundin et al., 1995). Thus, the primary purposes of the current research were to explore the hemodynamic cardiovascular stress responses among the three major ethnic groups in Singapore and investigate its generalisability across different experimental tasks.

In this study, the CVR of three major ethnic groups (Malay, Chinese and Indian) in Singapore was investigated in response to three tasks. Current evidence suggests that hostility affects CVR primarily for tasks that involve interpersonal challenge (e.g. harassment) (Bishop and Robinson, 2000; Everson et al., 1995; Smith, 1992; Suls and Wan, 1993). With this in mind, three experimental tasks were selected. Mental arithmetic (MA) is a

cognitive task involving no interpersonal challenge, number reading (NR) is a non-interpersonally challenging task with low cognitive effort whereas anger recall (AR) is an emotional cognitive task that can be considered to involve interpersonal challenge or at least the recall of such challenge. The AR task has been shown to be related to hostility (Christensen and Smith, 1993). However, AR involves speech which evokes changes in blood pressure on its own and can add error variance to the task (Kamarck, 1992). Hence, we included a neutral speech task (NR) to control for the effects of speech with the AR.

To date a number of measures of anger and hostility have been related to CVR. These have included paper and pencil measures (e.g. Cook and Medley Hostility Scale; Cook and Medley, 1954) as well as interview based measures (e.g. interpersonal hostility assessment technique; IHAT; Haney et al., 1996). Current evidence suggests that interview-based measures show the strongest relationship to both CHD (Miller et al., 1996) and CVR (Suls and Wan, 1993). In line with this the IHAT was used to measure the behavioral aspect of dispositional hostility in this study.

2. Method

2.1. Participants

This experimental study constituted part of a larger study involving 254 male patrol officers. Other portions of this larger study involved ambulatory blood pressure monitoring (cf. Bishop et al., 2003) and studies of stress and coping using questionnaires (cf. Bishop et al., 2001; Diong et al., submitted for publication and Tong et al., in press). Officers with heart problems, hypertension or who had undergone any form of heart surgery were excluded. Data from 11 officers were not included due to incomplete data, a history of heart problems or hypertension. Ethnicity was determined by the classification on their national identification cards. The remaining 243 included 81 officers from each of the three major ethnic groups in Singapore—Chinese, Malay and Indian. Mean age of the officers was 27.6 years (range, 19–51).

Of the original 243 officers, a total of 125 officers volunteered for this experimental study. To encourage participation, participants for this study were given a token worth S$5 (US$2.94) and were also eligible for a lucky draw that consisted of S$1700 (US$1000) worth of prizes. The experiment was conducted between January 2000 and August 2000. Data for 11 participants from the 125 participants who volunteered for this experimental study were discarded due to equipment failure or because of baseline readings that suggested undiagnosed hypertension. This reduced the final sample size to 114. Binary logistic regression was done to ascertain whether the officers who participated in this experiment ($n=114$: 35 Chinese, 40 Indians and 39 Malays) differed in hostile behavior index (HBI) and body mass index (BMI) from the officers that did not ($n=129$: 46 Chinese, 41 Indians and 42 Malays). The results showed that the predictive power of these variables was not significant, χ^2 (9, $n=237$) = 8.89, $P=0.45$. Pearson χ^2 also revealed no significant difference for ethnic distribution between those that participated in this study and those that did not, χ^2 (2, $n=243$) = 0.00, $P=1.00$. Thus, the selection process was not biased in terms of these variables.

Table 1 indicates that the three ethnic groups involved in this experimental study were similar on all variables except religion, BMI and family history of hypertension. As was expected, religion was closely associated with ethnicity. BMI was significantly different among the three ethnic groups, $F(2, 111)=4.97$, $P=0.009$, $\eta^2=0.08$. With Tukey's HSD set at 0.05, the BMI of the Chinese group was significantly lower than that of the Indians and the Malays while the BMI of the Indians did not differ from that of the Malays. Family history of hypertension and ethnicity were also found to be significantly related, χ^2 (2, $n=114$) = 7.13, $P=0.028$. Pairwise comparisons using Holm's sequential Bonferroni method to control for Type I error at $\alpha=0.05$ found that a significantly higher number of Malays (43.6%) and Indians (55%) had a family history of hypertension when compared to the Chinese (25.7%). These two variables were entered in subsequent analyses as covariates.

Table 1
Sample characteristics ($n=114$)

Ethnic group	Chinese	Malays	Indians	Total
Sample size	35	39	40	114
Age, mean (S.D.)	25.3 (5.3)	28.0 (5.5)	28.1 (7.1)	27.3 (6.1)
Religion (%)				
Christianity	1 (2.9)	0 (0)	3 (7.5)	4 (3.5)
Islam	0 (0)	39 (100)	14 (35.0)	53 (46.5)
Buddhism	27 (77.1)	0 (0)	0 (0)	27 (23.7)
Sikhism	0 (0)	0 (0)	3 (7.5)	3 (2.6)
Hinduism	0 (0)	0 (0)	19 (47.5)	19 (16.7)
Others	0 (0)	0 (0)	1 (2.5)	1 (.9)
None	7 (20.0)	0 (0)	0 (0)	7 (6.1)
BSA, m^2 (S.D.)	1.80 (.15)	1.88 (.16)	1.90 (.19)	1.86 (.17)
BMI[a], kg/m^2 (S.D.)	23.03_a (3.10)	25.01_b (4.05)	25.48_b (3.27)	24.56 (3.64)
Positive family history of hypertension[a] (%)	9_a (25.7)	17_b (43.6)	22_b (55.0)	48 (42.1)
Transformed IHAT Scores (S.D.)	−1.23 (.51)	−1.05 (.41)	−1.11 (.53)	−1.13 (.48)
Cook and Medley Ho Scale	22.54 (6.17)	23.86 (7.60)	23.00 (8.41)	23.16 (7.45)

[a] Means sharing a common subscript are not significantly different at $P<0.05$.

2.2. Design

This experimental study included two covariates (BMI and family history of hypertension), three independent variables and six dependent variables. The independent variables were ethnicity, HBI and task. Ethnicity was a between participant variable with three levels (Chinese, Malay and Indian). Hostility assessed via the HBI, was between-participant continuous variable. Task was a within participant variable with three levels (MA, NR and AR). Dependent variables are discussed under Section 2.5.

2.3. Equipment

Experimental stimuli and questionnaire items were presented on a 15 inch CRT monitor connected to a laptop computer (Toshiba Satellite 4030CDT). The experimenter manipulated the computer CRT display with the laptop. The experimenter and the participant sat opposite each other with a partition between them. Participants received taped-recorded instructions and communication was via headsets worn by both the experimenter and the participant.

For each participant, impedance cardiogram data were obtained using the Minnesota Impedance Cardiograph Model 304B with the standard four mylar band electrode (Instrumentation for Medicine Inc., Greenwich, CT) configuration (Sherwood et al., 1990). Using the cardiac output program for Windows (COPWIN: Bio-Impedance Technology Inc., Chapel Hill, NC), approximately 60 cardiac cycles were averaged to produce reliable averaged waveforms while blood pressure was taken simultaneously. When blood pressure is entered, the program calculates the total peripheral resistance and mean arterial pressure. A transducer was placed to the left of the participant's sternum to detect heart sounds (i.e. phonocardiogram). An automated auscultatory blood pressure monitor (Model SD-700A: Industrial & Biomedical Sensors Corporation, Waltham, MA) measured blood pressure. The blood pressure readings obtained from this unit correlate highly ($r>0.90$) to those obtained with a mercury sphygmomanometer (Davis et al., 2000). The blood pressure cuff was placed on the non-dominant arm.

2.4. Psychological measures

Trait hostility was obtained via the structured interview (SI) assessed using the IHAT (Haney et al., 1996). This psychological measure was obtained in the initial phase of the larger project between November 1998 and March 1999. Two male interviewers conducted the SI with precaution

taken to ensure an even distribution of the three ethnic groups between the two interviewers. To obtain an estimate of inter-rater reliability for the IHAT, approximately 25% of the tape-recorded interviews were randomly selected and assessed by two female researchers who were trained by Thomas Haney, the chief formulator of the IHAT. Component scores for Irritation, Hostile Evade/Withhold, Indirect Challenge, Direct Challenge were combined and divided by the total number of questions asked during the interview to yield the HBI. Correlation between the two raters was 0.75, $P < 0.001$, $n = 62$. Given this acceptable inter-rater reliability, all remaining interviews were assessed by one rater. As the kurtosis and positive skewness of the raw HBI scores were statistically significant, a logarithmic transformation of the HBI scores was done to obtain a normal distribution. The Cook and Medley (1954) Hostility Scale was also not used in this study as there have been questions raised regarding its cross-cultural construct validity in Singapore (Bishop and Robinson, 2000).

A 15 item Mood Adjective Checklist, derived from the UWIST Mood Adjective Checklist (Matthews et al., 1990), was used to track changes in mood during the NR and AR tasks. It was restricted to these two tasks because (1) anger mood changes were most relevant to these two tasks, and (2) having the checklist before and after every task would have lengthened the whole experimental procedure, potentially discouraging officers from volunteering. The items consisted of four items measuring Hedonic tone ('Satisfied', 'Happy', 'Cheerful', 'Sad'), five items measuring Anger ('Impatient', 'Annoyed', 'Angry', 'Irritated', 'Grouchy'), three items measuring Tense arousal ('Anxious', 'Relaxed', 'Calm') and three items measuring Energetic arousal ('Alert', 'Energetic', 'Tired'). The items were randomly ordered each time and displayed on the computer monitor in front of the participant for their response using the MEL Professional program (Psychology Software Tools Inc., Pittsburgh, PA). All items were rated on a 4-point scale: '1' for 'Definitely Not', '2' for 'Slightly not', '3' for 'Slightly' and '4' for 'Definitely'.

2.5. Physiological measures

The six physiological measures analyzed were systolic blood pressure, diastolic blood pressure, heart rate, cardiac output index, total peripheral resistance index and pre-ejection period. Cardiac output index and total peripheral resistance index were calculated by dividing cardiac output and total peripheral resistance by body surface area (BSA: Mosteller, 1987) to control for BSA. Systolic blood pressure, diastolic blood pressure and heart rate represent general cardiovascular indices that are most commonly measured in other studies, while cardiac output index and total peripheral resistance index represent the hemodynamic factors affecting blood pressure. Pre-ejection period is used here as an index of cardiac sympathetic activity.

2.6. Procedure

Participants had rotating work shifts that included a 2 consecutive days' rest. To control for circadian rhythm due to their work schedules, the experimental session was held on the second day-off. The sessions were held on weekdays and participants were scheduled for one of three time slots—10.00 h, 13.00 h and 15.00 h. Each session lasted approximately 1.5 h.

Upon arrival the participant was led into the experimental room and briefed about the experimental study. After this the electrodes and blood pressure cuff were attached. He was then told to relax for approximately 8 min and was encouraged to think relaxing thoughts (e.g. relaxing at the beach). During this time, an audio track of forest nature sounds without accompanying music was played (Oreade Music, ORN 5419-2). This constituted the first baseline for physiological data collection. Blood pressure readings were taken at the first, third, fifth and seventh minute into the baseline. The COPWIN program also took impedance readings at the same time the blood pressure monitor was activated. After the end of 8 min, the participant was told to proceed with either the MA or NR/AR task. The NR preceded the AR without an intervening baseline. The presentation order of the two tasks was counterbalanced within each

ethnic group. Baseline measurements were taken before and after the two task sessions. All baselines lasted 8 min.

2.7. Tasks

2.7.1. Mental arithmetic

A computer program displayed mathematical problems ranging from subtracting or adding one digit numbers to subtracting or adding three digit numbers. The participant responded by tapping either of two keys on the keyboard using his dominant hand to indicate whether the given answer was correct or incorrect. A 3-s time limit was given for the required response. Participants were told that this is a good measure of general ability. The program automatically adjusted the difficulty of the arithmetic problems based on the participants' responses to yield approximately 70% correct responses. This task took approximately 4 min. The blood pressure and impedance cardiogram readings were taken at the first and the third minute of the task.

2.7.2. Number reading

Each participant was asked to read a printed page of random numbers. They were to read the numbers for approximately 5 min. The blood pressure cuff was inflated at the first and third minute into the task. Past studies have used the reading of non-emotional passages but this may elicit anxiety in participants for whom English is not their first language. A random NR task was chosen because it would present no difficulties with respect to deciphering numbers or their pronunciations.

2.7.3. Anger recall

After reading the random numbers participants were told to think of a time that had occurred within the last 6 months when someone made them really angry. They were told to recall the situation, the people involved, their reaction, thoughts, feelings and reaction for 1 min. During this phase no measurements were taken. After 1 min the participant was asked to talk about the incident for 5 min. If a participant stopped before the end of 5 min, a male experimenter gave standardized prompt questions. Standard prompts included: 'Describe in detail what you were feeling at that time', 'What were your thoughts then?', 'What did you do when that event occurred?', 'How did the other person react?', and 'What was it about the event that made you angry?' The blood pressure cuff was inflated at the first and third minute of the task and disclosures were tape-recorded.

The 15 item Mood Adjective Checklist was presented to participants via the computer screen before and after the NR and after the AR. Participants responded using designated keys on the computer keyboard. At the end of the experiment, the various recording devices were removed from the participant and a short debriefing session was given whereby the general aims of the experimental session were explained to the participant.

2.8. Statistical analysis

Stepwise hierarchical multiple regression with repeated measures was done for each dependent variable (Pedhazur, 1982). Hostility was centered and entered into the regression model as a continuous variable and separate variables (vectors) were generated to represent the categorical variables (ethnicity and task) using effect coding. Two vectors each were created to represent ethnicity and task. Interaction terms were computed by taking the product of vectors representing the main effects. Criterion scaling was used to obtain between-subjects variance. For the criterion scaling the sum was taken of the three reactivity scores for the DV in question and entered into the regression equation after the vectors representing between subjects effects. Residual error variance was used as the within-subject error variance. For each dependent variable, the following independent variables were entered in the order listed: BMI and family history of hypertension (covariates), ethnicity, hostility, ethnicity × hostility, criterion scaling, task, task × ethnicity, task × hostility, task × ethnicity × hostility. Details of this method are described in Pedhazur (1982). SPSS version 10 was used for all analyses.

3. Results

3.1. Data reduction and baselines

The last two readings for the first baseline were averaged for each dependent variable. Reactivity was calculated by subtracting the baseline value from the values obtained during each experimental task. Evidence suggests that subtraction scores are as stable and valid as more complicated methods of deriving reactivity data (Llabre et al., 1991), especially when between task comparisons are made (Gerin et al., 1993). The means and standard deviation (S.D.) of the six dependent variables for the first baseline and the three experimental tasks are listed in Table 2.

3.2. Main analyses

3.2.1. Systolic blood pressure

For systolic blood pressure, a significant main effect was obtained for task, $F(2, 216) = 69.71$, $P < 0.0001$, $R^2 = 0.123$ as well as a significant ethnic by HBI by task interaction, $F(4, 216) = 6.82$, $P < 0.0001$, $R^2 = 0.024$. As can be seen in Table 2, the largest systolic blood pressure reactivity was obtained for AR ($M = 13.14$ mmHg) followed by MA (8.70) and NR (4.95). Examining the ethnic by HBI by task interaction it can be noted that the regression slopes for all three ethnic groups between transformed HBI scores and systolic blood pressure reactivity were non-significant for MA and NR (range of $b = 0.21–2.60$). However, systolic blood pressure reactivity for AR was negatively related to HBI for Indians but positively related to HBI for the Malays (Fig. 1).

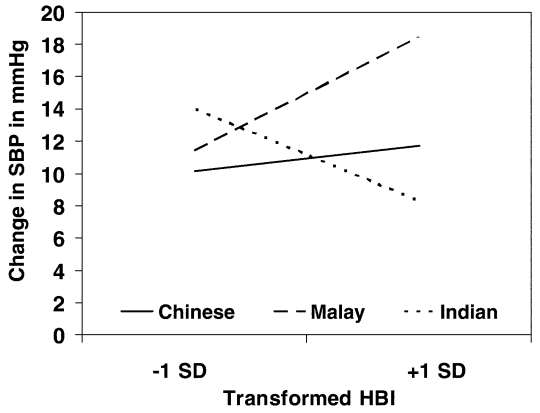

Fig. 1. Systolic blood pressure (SBP) reactivity as a function of transformed HBI scores and ethnicity for AR.

3.2.2. Diastolic blood pressure

For diastolic blood pressure a significant task main effect was found, $F(2, 216) = 25.28$, $P < 0.0001$, $R^2 = 0.085$. As with systolic blood pressure the largest diastolic blood pressure reactivity was found for AR (8.55) followed by MA (6.05) and NR (5.98) (Table 2). The Task by HBI interaction was significant, $F(2, 216) = 3.48$, $P = 0.03$, $R^2 = 0.012$, with transformed HBI scores negatively related to diastolic blood pressure reactivity for both the AR and MA. The relationship between HBI scores and diastolic blood pressure reactivity was slightly positive for the NR.

3.2.3. Heart rate

For heart rate a significant ethnicity by Task interaction was found, $F(4, 216) = 2.56$, $P = 0.039$, $R^2 = 0.014$. Post hoc analysis showed a significant difference for heart rate reactivity between the MA

Table 2
Means (S.D.) of cardiovascular responses by task*

	Baseline	MA	NR	AR
Systolic blood pressure	114.90 (7.62)	$123.60\ (11.04)_a$	$119.86\ (9.69)_b$	$128.05\ (12.43)_c$
Diastolic blood pressure	72.87 (8.30)	78.92_a (9.23)	78.85_a (10.21)	83.72_b (10.31)
Heart rate	74.65 (10.97)	77.72_a (10.36)	78.32_a (10.23)	78.34_a (10.57)
Cardiac output index	2.60 (0.54)	2.69_a (.64)	2.64_a (.59)	2.70_a (.55)
Total peripheral resistance index	817.42 (200.39)	$859.17_{a,b}$ (222.92)	856.54_a (213.39)	883.61_b (208.63)
Pre-ejection period	85.85 (13.14)	82.35_a (14.59)	86.96_b (13.13)	$84.62_{a,b}$ (17.39)

Note: Means sharing a common subscript do not have significant differences ($P < 0.05$) for reactivity scores.

Table 3
Means (S.D.) for heart rate reactivity by ethnic group and task

	MA	NR	AR
Chinese ($n=35$)	3.84 (6.83)$_a$	3.41 (3.53)$_a$	3.14 (4.54)$_a$
Indian ($n=40$)	1.54 (5.07)$_a$	3.85 (4.61)$_b$	2.83 (5.92)$_{a,b}$
Malay ($n=39$)	3.95 (5.50)$_a$	3.71 (4.19)$_a$	5.08 (4.98)$_a$

Note: Means within a row sharing a common subscript are not significantly different at $P<0.05$.

and NR task for Indians with lower heart rate reactivity for MA than NR (Table 3).

3.2.4. Cardiac output index

For cardiac output index a significant ethnic by HBI interaction was obtained, $F(2, 106)=4.23$, $P=0.017$, $R^2=0.045$. This interaction is shown in Fig. 2. Whereas the regression lines for Chinese and Malays were relatively flat and neither differed significantly from zero the slope for the Indians was significantly positive, $b=0.30$, S.E.$=0.06$, $t(39)=4.86$, $P=0.000019$.

3.2.5. Total peripheral resistance index

As with systolic blood pressure and diastolic blood pressure a significant Task main effect was found for total peripheral resistance index, $F(2, 216)=3.73$, $P=0.026$, $R^2=0.011$, with AR showing the greatest increase (Table 2). In addition, similar to cardiac output index, the ethnic by HBI interaction was also significant, $F(2, 106)=5.51$, $P=0.0053$, $R^2=0.058$. *T*-tests revealed that the slope for the Indians was significantly negative, $b=-111.98$, S.E.$=23.01$, $t(39)=4.87$, $P=0.000019$, whereas the slopes for Chinese and Malays were not significantly different from zero. This interaction is shown in Fig. 3.

3.2.6. Pre-ejection period

For pre-ejection period, there was a significant Task main effect, $F(2, 216)=7.78$, $P=0.0006$, $R^2=0.023$. As can be seen in Table 2, pre-ejection period showed a strong reduction for MA (-3.57) with a smaller reduction for AR (-1.35) and an increase for NR (1.08).

3.3. Anger mood changes during NR and AR

The ratings for the items in each mood scale were summed. The pattern of results in Table 4 showed that AR is associated with a significant decrease in Hedonic Tone and a significant increase in Anger compared to baseline and NR. Both NR and AR increased Tense arousal while no task differences were found for Energetic arousal.

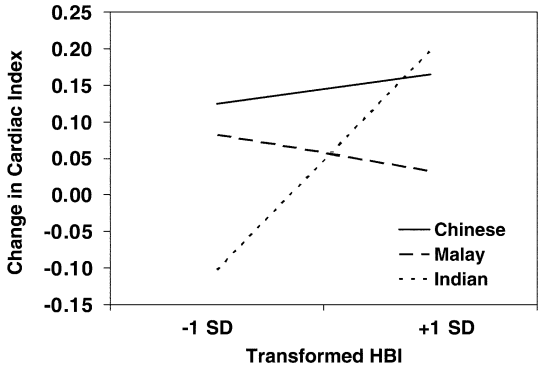

Fig. 2. Cardiac output index (CI) reactivity as a function of transformed HBI scores and ethnicity.

To test for the interaction of HBI with mood changes, hierarchical regression with interaction terms was performed using transformed HBI scores and AR mood reactivity scores as continuous between-participant variables. Task and ethnicity were the categorical between participant variables. Similar results were obtained for systolic blood pressure and heart rate but there were no significant results involving AR mood reactivity scores.

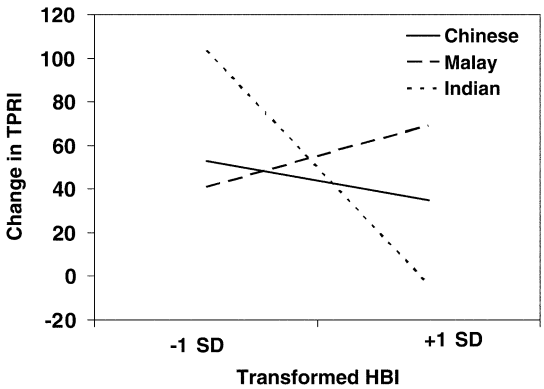

Fig. 3. Total peripheral resistance index (TPRI) reactivity as a function of transformed HBI scores and ethnicity.

Table 4
Means (S.D.) for the Mood Scales at baseline, after NR and after AR

	Baseline	After NR	After AR
Hedonic tone	12.39 (2.29)	11.80 (2.68)	10.46 (3.15)
Anger	7.88 (2.96)	9.09 (3.57)	11.03 (3.86)
Tense arousal	5.87_a (1.88)	6.33_b (1.95)	6.74_b (2.10)
Energetic arousal	8.20_a (1.90)	8.07_a (1.98)	8.29_a (2.13)

Note: Means within a row sharing a common subscript are not significantly different at $P<0.05$.

4. Discussion

As expected the three tasks differed significantly in CVR. The AR task was associated with the greatest systolic blood pressure, diastolic blood pressure and total peripheral resistance index reactivity suggesting that it is more stress provoking than the other two tasks. Comparison of CVR for the AR and NR tasks indicates that reactivity to AR cannot be solely accounted for by the speech production mechanism (Siegman et al., 1990). Interestingly enough both the NR and AR elicited increased feelings of self-reported anger. The finding of Anger arousal for NR may reflect participant appraisal of the task. A lack of understanding of the purpose of the NR might have led participants' to appraise it as a purposeless and embarrassing task leading to increased feelings of anger. The increased feelings of anger reported by the participants after AR compared to the baseline and post NR anger mood shows that the AR was effective in eliciting feelings of anger.

Turning to the prime concerns of this study, the relationship of hostility to CVR and ethnic differences, three findings are of note. For systolic blood pressure significant differences were obtained for AR such that systolic blood pressure reactivity was a positive function of hostility for Malays but this was not true for Indians. For cardiac output index and total peripheral resistance index a different pattern was obtained such that across tasks HBI was positively related to cardiac output index reactivity and negatively related to total peripheral resistance index reactivity for Indians whereas these relationships were not found for Chinese and Malays. The absence of significant ethnicity by HBI by Task interaction for cardiac output index and total peripheral resistance index indicates that the ethnicity by HBI interaction generalised across task. In addition, the lack of an ethnic main effect also shows that the three ethnic groups do not have a general propensity to display reactivity traits independent of trait hostility.

On the whole, the pattern of hemodynamic CVR results is consistent with cardiovascular disease patterns in Singapore for Indians. The pattern of results for cardiac output index and total peripheral resistance index is consistent with cardiovascular disease patterns in that the finding of increased cardiac output index reactivity and decreased total peripheral resistance index reactivity as a function of hostility for Indians suggests that high hostile Indians are cardiac reactors, at least for the tasks used in this research. Combined with evidence that cardiac reactors may be at higher risk of developing CHD (Sundin et al., 1995) the results for cardiac output index and total peripheral resistance index are consistent with the higher rates of CHD observed for Indians in Singapore. The increased cardiac output index reactivity and decreased total peripheral resistance index reactivity among high hostile Indians indicates possible beta adrenergic hyper-reactivity. Sympathetic hyper-reactivity via stimulation of the adrenoreceptors has been associated with various cardiovascular diseases (Esler and Kaye, 2000). Further research using beta-blockade among high and low hostile males (defined via the HBI) may provide more insight into this issue.

This study is the first to cross-culturally investigate the relation of a psychosocial factor (i.e. hostility) and cardiovascular hemodynamic profile among different ethnic groups in an Asian context. Future research should investigate how such an interaction between hostility and hemodynamic profile among different ethnic groups is related to

other cardiovascular disease risk indices in Singapore.

The results of this study showed that, with the exception of systolic blood pressure, task effects involving trait hostility were non-significant. Suls and Wan's (1993) meta-analysis concluded that trait hostility is related to CVR under provocation or interpersonal tasks. This conclusion was based on two studies, one of which sampled females (Anderson et al., 1986) while the other (Everson et al., 1995) involved harassment. Bishop and Robinson (2000) also used the harassment paradigm. As such it appears that trait hostility may be related to CVR primarily in the presence of harassment and results obtained with the harassment paradigm may not be generalizable to tasks like the AR. In this study, although harassment was not utilised, systolic blood pressure reactivity showed a non-significant but negative relationship with trait hostility for the Indians along with a significant positive relationship for the Malays for AR. Comparison with the results obtained in Bishop and Robinson (2000) is limited by the fact that hostility in that study was assessed hostility via the Spielberger State Trait Anger Expression Inventory (1988), a measurement of dispositional anger rather than hostile behavior responding (HBI). It is also unclear whether the results obtained in that study are complementary or contradictory to the present one; if systolic blood pressure changes found by Bishop and Robinson (2000) for Indians were due to a similar hemodynamic profile as that obtained here, the results could be interpreted as complementary. Though there are sufficient differences between the two studies to limit comparisons, a few other studies have also found negative or null associations between hostility and blood pressure reactivity (Carroll et al., 1997; Felsten, 1995). The cardiovascular system is a self-regulatory homeostatic system and there is increasing evidence to suggest that both hyper- and hypo-reactivity may represent a potential pathological inability of the cardiovascular system to maintain blood pressure fluctuations within boundaries (Sloan et al., 1999). A recent 3-year prospective study demonstrated that daytime systolic blood pressure variability was associated with increased atherosclerosis of the carotid arteries (Sander et al., 2000). Thus, the results obtained by Bishop and Robinson (2000) and this study suggest that the increased risk of cardiovascular disease for Indians could be mediated by a large variability in systolic blood pressure regulation.

It is interesting to note that neither BMI nor family history of hypertension showed any relationship to CVR in this sample even though past research has found such linkages and these variables are commonly used as covariates in studies of CVR (cf. Lawler et al., 1998; Stewart and France, 2001). At this point it is not entirely clear why this was the case. One possibility for the negative results concerning family history of hypertension is that the self-report measure used was not reliable. Although they may have attempted to be thorough in their answers officers may not have been privy to information on family history of hypertension and thus such family history may have been underreported. This argues for a more in-depth assessment of family history which could involve requesting participants to actively seek out information on family history of hypertension and other cardiovascular conditions rather than simply respond to a single item in a questionnaire. Since height and weight were measured at the time of the experiment the unreliability argument does not apply to the negative results for BMI. However, it should be pointed out that BMI does not always show significant relationships to CVR as evidenced by the non-significant effects for BMI as a covariate obtained in some studies (cf. Stewart and France, 2001).

Caution should be taken when inferences are made from the results obtained in the current study. Firstly, the results may not be generalised to females since the sample used in this study consisted entirely of males. Research has shown that gender is an important factor in psychophysiological research (Lawler et al., 1993). Secondly, the sample comprised of patrol officers. Though there are no published data comparing stress levels with the other occupations in Singapore, police work can be considered a highly stressful occupation. Furthermore, stress encountered by patrol officers during the course of their law enforcement duties is different from that experienced in other occu-

pations. As such these findings should be replicated with other samples. Thirdly, the reactivity for the various physiological variables obtained in this study was modest. Heart rate reactivity was approximately 3–4 beats per minute while diastolic blood pressure reactivity for MA (regarded as a more stressful task) was similar to the NR task. The mild stress elicited by these tasks may limit the generalisability of the findings obtained in this study. Perhaps this was due to an absence of any form of reward contingent on performance. Future studies may wish to include some form of performance-contingent reward in order to increase the utility of these tasks as laboratory stressors.

The clinical implications of the results of this study are that interventions should be done with both hostility and ethnicity in mind. The different hemodynamic profiles among high hostile individuals are different particularly for Indian males. This could imply that Indian males tend to have a reactive blood pressure regulation, which stresses the circulatory system and increases the risk of developing cardiovascular disease.

Further studies are needed to replicate and explore further the results obtained in this study. Moreover, research into the possible existence cultural differences in the manifestations of hostility would help illuminate possible explanations for the role of ethnicity within the framework of hostility and reactivity traits.

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