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The effect of expressing anger on cardiovascular reactivity and facial blood flow in Chinese and Caucasians

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Abstract

Blood pressure, heart rate, and changes in facial and finger blood flow were monitored in 24 male Chinese and 24 male Caucasians while they described anger-provoking incidents and read out neutral material, either loudly and rapidly or softly and slowly. Describing the incidents loudly and rapidly heightened anger ratings and enhanced digital vasoconstriction but not blood pressure or heart rate; however, anger enhanced blood pressure during soft, slow speech. Facial blood flow increased during anger expression, irrespective of speech style, but decreased when neutral material was read out. The findings suggest that an increase in facial blood flow reduces peripheral vascular resistance during anger expression, and that baroreflexes attenuate increases in heart rate and blood pressure. Racial background did not influence subjective reports or physiological responses, possibly because the procedure did not draw strongly enough on cultural taboos.

Descriptors: Anger, Cardiovascular reactivity, Blood pressure, Facial flushing, Race

The verbal expression of anger may heighten cardiovascular activity and enhance the experience of anger itself. This was first demonstrated experimentally by Siegman, Anderson, and Berger (1990), who reported that anger ratings and blood pressure and heart rate were higher when participants described anger-provoking incidents loudly and quickly than when similar incidents were described softly and slowly. In addition, blood pressure and heart rate were higher when participants described anger-provoking incidents loudly and rapidly than when they described neutral incidents in this way. Siegman and Snow (1997) went on to report that recalling an anger-provoking incident without describing it did not increase blood pressure or heart rate, although participants reported that they felt angry. Siegman and Snow concluded that the verbal expression of anger influences cardiovascular activity more strongly than unexpressed feelings of anger, and suggested that verbal expression may shape the nature and intensity of emotions such as anger, much like cognitive appraisal, facial expression, and physiological arousal.

The face often flushes during anger (e.g., Darwin, 1872/1965), despite an increase in sympathetic vasoconstriction that limits blood flow through other parts of the cutaneous circulation; however, facial pallor may sometimes develop during fits of rage (Darwin, 1872/1965) or when fear is mixed with anger (Drummond, 1997a). Surprisingly little is known about the precursors to these opposing changes in facial blood flow. In an exploratory investigation in our laboratory, facial blood flow was monitored in female participants while they tried to assemble a difficult three-dimensional jigsaw puzzle (Drummond, 1999). Increases in blood flow were greater when a female research assistant made derogatory comments about the participant's performance than when she made encouraging comments. The stimulus for facial flushing in this study is uncertain because participants reported feeling embarrassed as well as angry, particularly when they were the target of derogatory comments. Speculatively, the lack of opportunity to express anger verbally heightened feelings of embarrassment, which contributed to increases in facial blood flow.

In the present study, changes in blood pressure, heart rate, and blood flow in the face and fingers were monitored while participants described anger-provoking incidents or read out neutral material loudly and quickly, or softly and slowly (Siegman, 1993; Siegman et al., 1990; Siegman & Snow, 1997). It was hypothesized that loud, rapid speech would enhance feelings of anger and heighten increases in blood pressure and heart rate when participants described anger-provoking incidents. Vasoconstriction in resistance vessels (except in skeletal muscle, the heart, and the brain) contributes to increases in blood pressure during psychological stress (e.g., Folkow, 1982). Thus, digital blood flow was expected to decrease when participants described anger-provoking incidents, more so when the incidents were described loudly and quickly. Because facial pallor is said to develop during fits of rage (Darwin, 1872/1965), it was hypothesized that facial blood flow would also decrease when participants described anger-provoking incidents loudly and quickly. However, the face may flush during less in-

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tense anger (Darwin, 1872/1965), possibly as part of a homeostatic mechanism that attempts to oppose increases in peripheral vascular resistance (Drummond, 1999). Thus, it was hypothesized that facial blood flow would increase when the incidents were described softly and slowly.

Although emotions such as fear and anger appear to be biologically innate (e.g., Izard, 1994), the rules on how and when these universal emotions can be expressed may differ across cultures (Matsumoto, 1994). For example, in an experimental investigation of emotional expressiveness in Americans and Japanese, Ekman (1972) found that facial expressions of anger, disgust, and sadness were similar in both groups when participants watched stressful films by themselves. However, when interviewed afterwards about their experience by a member of their own culture, the Japanese tried to mask negative emotions by smiling whereas the Americans typically did not (Friesen, 1972). These findings suggest that culturally based attitudes and display rules may alter the nonverbal expression (and possibly the experience) of anger and other negative emotions in some settings.

Siegman's earlier studies were conducted in Israel (Siegman, 1993; Siegman et al., 1990), whereas the most recent replication study was carried out in Baltimore (Siegman & Snow, 1997). The similarity of findings across these three studies suggests that the anger-enhancing effect of expressing anger generalizes across cultures. To address this issue more explicitly in the present study, participants were of Caucasian or Chinese descent. Because maintaining social harmony is important in the Chinese culture, it was expected that Chinese participants would feel less comfortable about expressing anger loudly than Caucasians. Berkowitz (1999) postulated that sources of negative affect unrelated to anger can activate or heighten the intensity of anger. Thus, it was hypothesized that feelings of discomfort, generated by having to express anger loudly, would heighten anger and increase physiological activity in the Chinese participants. However, it was predicted that anger ratings would be lower in Chinese than Caucasians because of cultural taboos about admitting that they were angry.

Method

Participants

The sample consisted of 48 men aged between 18 and 35 years. Twenty-four were Caucasian (mean age 23.5 ± 5.4 years) and 24 were of Chinese origin who had come to Australia from Singapore or Malaysia to undertake a university degree (mean age 23.0 ± 2.2 years). Men were selected as participants because cardiovascular responses typically are greater in angry men than women (Burns, 1995; Burns & Katkin, 1993; Lai & Linden, 1992; Lawler, Harralson, Armstead, & Schmied, 1993). None of the participants were being treated for hypertension or other health problems that may have influenced cardiovascular activity.

Each participant gave his informed consent for the procedures, which were approved by the Murdoch University Human Research Ethics committee.

Apparatus

Blood pressure and heart rate were monitored once each minute by an M4 Omron automatic digital blood pressure monitor (Omron Corporation, Tokyo, Japan) attached to the participant's dominant arm. The Omron monitor detects blood pressure to an accuracy of ±2% and the pulse to an accuracy of ±5%. Systolic and diastolic blood pressures were detected oscillometrically (Geddes, 1970) and displayed digitally on the monitor's front panel to an accuracy of 3 mmHg when simultaneously checked against the auscultatory method in eight individuals [$r(6) = 0.994$ for systolic blood pressure and $r(6) = 0.987$ for diastolic blood pressure]. Cuff deflation was approximately 5 mmHg/s. Heart rate was calculated automatically by counting the number of blood pressure oscillations during each cycle of blood pressure measurement. To detect changes in skin blood flow, pulse transducers (photoplethysmographs, Grass Instruments Company, Quincy, MA, USA) were attached to the left or right side of the forehead and to the index finger of the participant's nondominant hand with adhesive tape. The pulse transducer on the forehead was placed 4 cm from the midline and 2 cm above the eyebrow, and covered with a black headband made of soft elastic fabric to reduce random variation in illumination of the skin around the recording site. The headband was stretched slightly to hold it in place. The pulse transducer attached to the index finger was sheltered from light with a foam rubber insert and was secured in place with a velcro holder. The pulse transducers detected relative changes in blood flow, but did not measure flow in absolute terms (Drummond & Lance, 1981, 1992). Physiological signals were sampled 100 times/s with a Biopac MP100 data acquisition system and stored, displayed, and averaged using Acknowledge software (Biopac Systems, Santa Barbara, CA) on a personal computer.

Procedure

The experiment was carried out in a temperature-controlled laboratory maintained at 22 ± 1 °C. Participants were asked not to consume food or drinks containing caffeine for 10 hr before they attended the laboratory.

Before cardiovascular activity was monitored, the participant recalled four incidents that had made him angry and wrote down a few words that described each incident. These key words were later used as cues when the participant was asked to describe the incidents to the experimenter. The participant also practiced speaking loudly and rapidly (2–3 words/s), and softly and slowly (approximately 1 word/s).

The experiment began with a 10-min period of relaxation, followed by four tasks each lasting 5 min. The tasks were separated by 6 min of rest. Because the four tasks could be presented in 24 different orders, the tasks were administered in a different order to each of the 24 participants in each group. Two of the tasks required participants to read aloud some neutral material (gardening passages), either loudly and quickly or softly and slowly. The experimenter (SHQ, a Chinese woman) used hand signals to prompt the participant to maintain the required rate and loudness of speech. In the other two tasks, the participant described incidents that had made him feel angry, either loudly and quickly or softly and slowly. The experimenter prompted the participant with a list of standard questions about the time and place of the incident, who was involved, what happened, what was said, the participant's and antagonist's emotional reactions as judged by autonomic disturbances, facial expressions, voice quality and gestures, and how the incident ended. The experimenter encouraged the participant to continue describing the incident by using prompts such as "go on," "tell me more," and "that must have made you angry." Two incidents were described in each 5-min task.

Before the first task and after each task, the participant filled out a rating scale consisting of the State Anger scale of the State Trait Anger Expression Inventory (Spielberger, 1991) mixed with two embarrassment items ("I feel embarrassed" and "I feel self-conscious") and eight other items to disguise the focus of the scale. In an attempt to balance the affective content of the scale, most of the filler items referred to various aspects of positive affect (e.g., "I feel like smiling" and "I am enthusiastic"). Each item was rated on a 4-point scale where 1 represented "not at all" and 4 represented "very much so."

Data Reduction

The 10 items of the State Anger scale were averaged to yield anger ratings at baseline and after each task. The change from baseline was then calculated for each task. The two embarrassment items were also averaged, and changes from baseline were calculated for each task.

Acknowledge software was used to measure the average trough-to-peak height of pulses (pulse amplitude) for the 5 min of each task. Because the recorded amplitude of pulses was influenced by individual differences such as skin pigmentation and the closeness of vessels to the skin surface, changes in pulse amplitude during each task were expressed as a percentage of the amplitude recorded for 2 min before the task. Blood pressure and heart rate were measured four times during each task, starting approximately 30 s after task onset. The difference between the mean level during each task and the level during the 3 min preceding the task was then calculated.

Statistical Analyses

Differences between Caucasians and Chinese in ratings and levels of blood pressure and heart rate at the start of the experiment were investigated with Student's *t* test. The change in physiological activity and anger and embarrassment ratings during the four tasks was then investigated in $2 \times 2 \times 2$ [Race (Caucasian, Chinese) $\times$ Anger (expression, control) $\times$ Speech Style (loud and rapid, soft and slow)] analyses of variance. Results are reported as the mean $\pm$ standard deviation.

Results

Baseline

Levels of blood pressure and heart rate were similar in Caucasians and Chinese at the start of the experiment (mean for systolic blood pressure 114 ± 10 mmHg; diastolic blood pressure 69 ± 7 mmHg; heart rate 70 ± 12 beats/min). At the start of the experiment, anger ratings averaged 1.1 ± 0.3 on the 1–4 scale (i.e., not at all angry) and embarrassment ratings averaged 1.5 ± 0.5 (i.e., very slightly embarrassed). Both sets of ratings were similar in Chinese and Caucasians.

Effect of Anger Expression and Speech Style on Anger and Embarrassment Ratings

Not surprisingly, anger ratings were higher after describing the anger-provoking incidents than after reading out the neutral material, $F(1,46) = 48.5$, $p < .001$ (see Figure 1). Nevertheless, anger ratings increased modestly after reading out the neutral material loudly and quickly. The largest increase in anger ratings was 0.6 ± 0.7 (i.e., approximately 20% of full-scale) after describing the anger-provoking incidents loudly and rapidly; this corresponded to an average rating of "slightly angry." Anger ratings were higher after speaking loudly and rapidly than after speaking softly and slowly, both for anger-recall and after reading out the neutral material [main effect for Speech Style, $F(1,46) = 21.7$, $p < .001$]. The Anger $\times$ Speech Style interaction was not significant. On average, ratings increased 0.4 ± 0.4 in Caucasians compared with 0.2 ± 0.4 in Chinese during the four tasks, $F(1,46) = 3.51$, $p = .067$. None of the interactions involving Race were significant, indicating that anger ratings tended to increase less in Chinese than Caucasians during all four tasks.

In contrast to anger ratings, increases in embarrassment were greater after reading out neutral material than after describing anger-provoking incidents, $F(1,46) = 5.98$, $p < 0.05$ (see Figure 1). Increases in embarrassment were greater when speaking loudly and rapidly than when speaking softly and slowly, $F(1,46) = 5.65$, $p < 0.05$. Embarrassment ratings increased most when reading out the neutral material loudly and rapidly; the mean increase of 0.4 ± 0.8 was 14% of full-scale and corresponded to an average rating of "slightly embarrassed." Embarrassment ratings were similar in Caucasians and Chinese.

Effect of Anger Expression and Speech Style on Physiological Activity

Physiological responses did not differ between Caucasians and Chinese (none of the main effects or interactions involving Race were statistically significant). The main influence on blood pres-

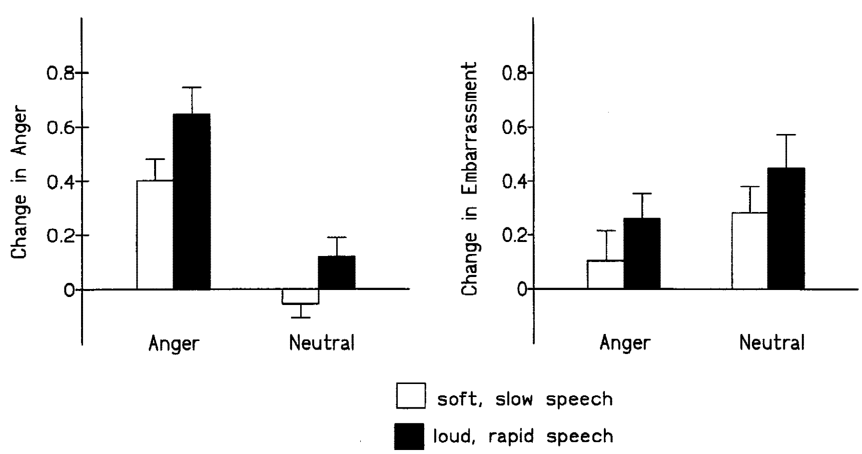

Figure 1. Changes in anger and embarrassment while describing anger-provoking incidents (anger condition), and while reading out gardening passages (neutral condition). Items were rated on a 4-point (i.e., 3-interval) scale; thus, a mean rating change of 0.3 is equivalent to a mean change of 10% of the full scale. In Figures 1–4, error bars represent standard errors.

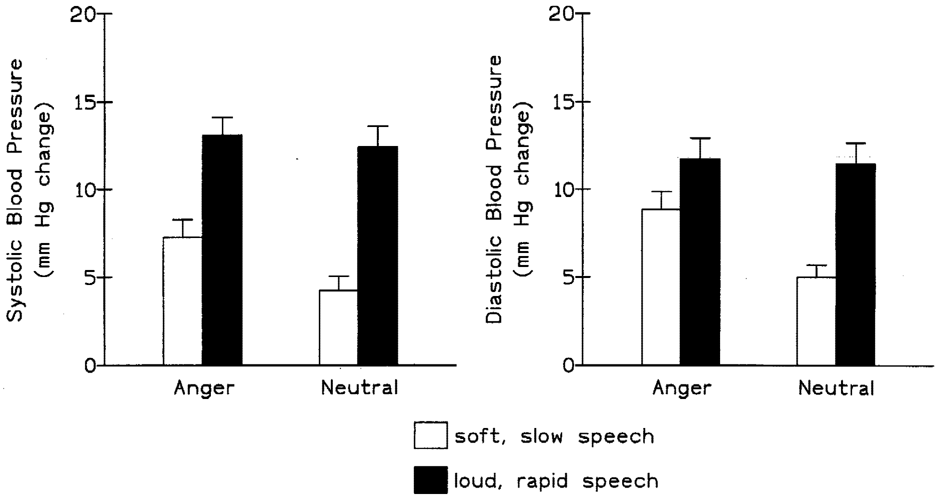

Figure 2. Changes in blood pressure while describing anger-provoking incidents (anger condition) and while reading out gardening passages (neutral condition).

sure responses was speech style, with larger increases during loud, rapid speech than during soft, slow speech [for systolic blood pressure, $F(1,46) = 99.7$, $p < 0.001$; for diastolic blood pressure, $F(1,46) = 31.6$, $p < 0.001$] (Figure 2). In addition, increases in systolic blood pressure were greater during anger expression than when reading out neutral material, $F(1,46) = 5.04$, $p < 0.05$.

The Anger × Speech Style interaction was not significant for systolic blood pressure. Nevertheless, exploration of the Anger main effect with paired *t*-tests indicated that increases in systolic blood pressure were greater when describing anger-provoking incidents softly and slowly than when reading out neutral material softly and slowly, $p < 0.01$. In contrast, the content of the material did not influence systolic blood pressure during loud, rapid speech.

The Anger × Speech Style interaction was significant for diastolic blood pressure, $F(1,46) = 4.60$, $p < 0.05$. To investigate the source of this interaction, paired *t*-tests were used to compare responses in the anger expression and neutral conditions for each speech style. These analyses indicated that increases in diastolic blood pressure were greater when describing anger-provoking incidents softly and slowly than when reading out neutral material softly and slowly, $p < 0.01$; however, diastolic blood pressure responses did not differ between the anger-provocation and neutral conditions during loud, rapid speech (Figure 2).

Investigation of the Anger × Speech Style interaction for heart rate, $F(1,46) = 9.75$, $p < 0.01$, indicated that increases were greater when reading out neutral material loudly and rapidly than when describing anger-provoking incidents using this style of speech, $p < 0.05$ (see Figure 3). However, heart rate responses did not differ between the anger-provocation and neutral conditions during soft, slow speech.

Forehead pulse amplitude increased during anger expression but not when reading out neutral material, irrespective of whether speech was loud and rapid or soft and slow, $F(1,45) = 29.7$, $p < 0.001$ (Figure 4). Neither the main effect for Speech Style nor the Anger × Speech Style interaction was statistically significant. In contrast to the forehead, finger pulse amplitude decreased during anger expression but not when reading out neutral material, $F(1,45) = 13.0$, $p < 0.001$ (Figure 4). Decreases in finger pulse amplitude were greater during loud, rapid speech than during soft, slow speech, $F(1,45) = 6.56$, $p < 0.05$.

Discussion

Ratings of Anger and Embarrassment

The findings confirmed that anger scores were greater when anger-provoking incidents were described loudly and rapidly than when the incidents were described softly and slowly (Siegman, 1993; Siegman et al., 1990; Siegman & Snow, 1997). Merely reading out neutral material loudly and rapidly resulted in higher anger scores than reading out the material softly and slowly, consistent with the notion that speech style can, by association, provoke anger. However, other possibilities should also be considered. For example, because some of the participants reported that they felt self-conscious when reading out the neutral material loudly and rapidly, the discomfort associated with feelings of embarrassment might have provoked anger. However, this possibility was weakened by the results of a post hoc analysis that indicated that embarrassment ratings were unrelated to anger ratings when participants read out the neutral material loudly and rapidly, Pearson's $r(46) = 0.25$, not

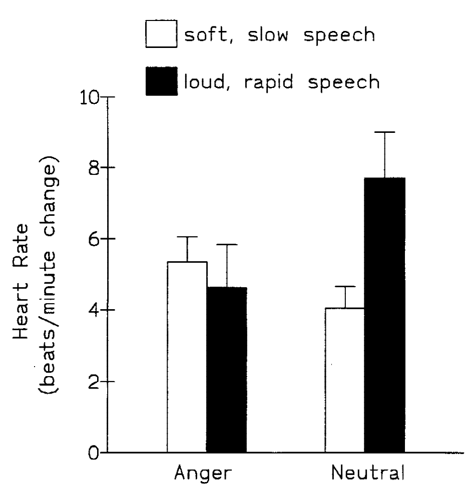

Figure 3. Changes in heart rate while describing anger-provoking incidents (anger condition) and while reading out gardening passages (neutral condition).

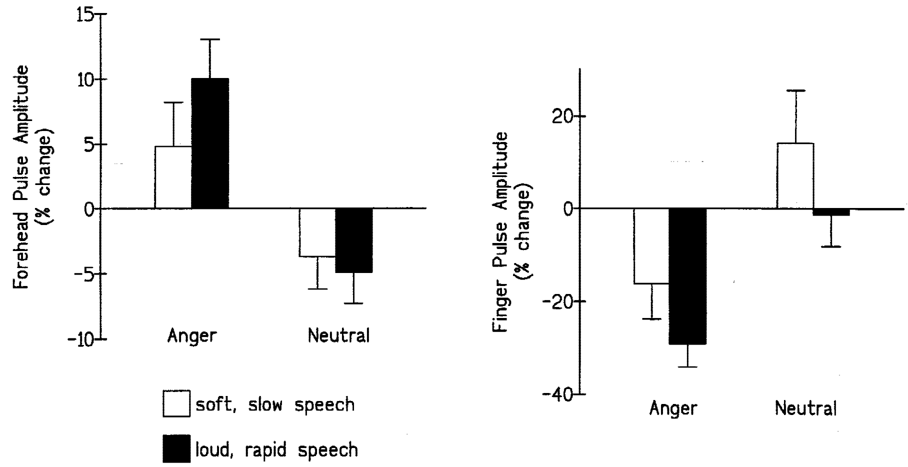

Figure 4. Changes in facial and finger blood flow while describing anger-provoking incidents (anger condition) and while reading out gardening passages (neutral condition).

significant. Embarrassment ratings increased only slightly when participants described anger-provoking incidents; thus, it seems likely that embarrassment had a minor influence, at best, on physiological activity when anger-provoking incidents were recalled.

Because it is important to maintain social harmony in the Chinese culture, it was hypothesized that anger ratings would increase less in Chinese participants than Caucasians during the experimental procedures. The findings were in the expected direction but did not achieve statistical significance, suggesting that a cultural bias was overshadowed by other unidentified influences on anger ratings. One possibility is that cultural display rules may be most influential in the presence of high-status individuals from the participant's culture. Because elderly men typically have highest status in the Chinese culture, the Chinese participants may have felt comfortable about reporting anger to the experimenter, a young, softly spoken Chinese woman enrolled in a postgraduate degree. A second possibility is that ratings were influenced by the demand characteristics of the experiment (i.e., to give accurate self-reports in a setting free from cultural censure). Third, Western values adopted by some of the Chinese participants might have diluted cultural effects. Unfortunately, the modest cultural influence on anger ratings weakened the likelihood of detecting a cultural influence on physiological activity during anger expression.

Blood Pressure and Heart Rate Reactivity

In the studies by Siegman and colleagues, speaking in an angry voice enhanced blood pressure responses during anger recall (Siegman, 1993; Siegman et al., 1990; Siegman & Snow, 1997). Specifically, blood pressure was higher when anger-provoking incidents were described loudly and rapidly than when the incidents were described softly and slowly; in addition, blood pressure was higher during anger recall than when neutral events were described loudly and quickly. Siegman's results were partly confirmed by the present findings. In particular, increases in blood pressure were greater during anger recall than when reading out neutral material, consistent with Siegman's view that the verbal expression of anger heightens physiological arousal. In contrast to Siegman's findings, however, the influence of anger on blood pressure was greater in the soft, slow speech condition than during loud, rapid speech. In fact, increases in blood pressure were virtually identical while describing anger-provoking incidents and reading out neutral material in the loud, rapid speech condition, suggesting that the dominant effect on blood pressure was the metabolic requirements of speech.

Although blood pressure increased when anger-provoking incidents were described loudly and rapidly, responses were smaller than in Siegman's studies. For example, Siegman and Snow (1997) reported increases in systolic blood pressure of 23.2 ± 12.1 mmHg when male participants described anger-provoking incidents loudly and rapidly, but systolic blood pressure increased only 13.1 ± 7.0 mmHg in the present study. The respective increases in diastolic blood pressure were 24.0 ± 13.1 mmHg and 11.8 ± 8.6 mmHg. The difference in response between the two studies was statistically significant both for systolic blood pressure, $t(58) = 3.81$, $p < 0.001$, and diastolic blood pressure, $t(58) = 3.93$, $p < 0.001$. Neither Siegman et al. (1990) nor Siegman (1993) reported their data as change scores, but systolic and diastolic blood pressures were substantially higher when participants described anger-provoking incidents loudly and rapidly than when neutral events were described loudly and rapidly. This effect was not observed in the present study.

Siegman et al. (1990) and Siegman and Snow (1997) reported that speaking in an angry voice enhanced heart rate responses during anger recall. However, Siegman (1993) was unable to demonstrate an effect of anger expression on heart rate reactivity, indicating that speech style during the expression of anger influences heart rate less consistently than blood pressure. In the present study, loud and rapid speech did not enhance heart rate responses when describing anger-provoking incidents; in fact, heart rate increased more when reading out neutral material loudly and rapidly than when describing anger-provoking incidents. This paradoxical finding is puzzling, but the clear dissociation between blood pressure and heart rate responses during anger recall suggests that increases in peripheral vascular resistance contributed primarily to the increase in blood pressure. Possibly baroreflexes triggered by increases in blood pressure attenuated increases in heart rate during anger recall.

The race or gender of the experimenter, the nature of prompts, or the experimenter's speaking style when prompts were given might have weakened the strength of effects and limited the generalization of findings in the present study. Cultural stereotypes appear to modify physiological activity in certain social encounters. For example, Vrana and Rollock (1998) reported recently that heart rate accelerated when black men approached and touched white men on the wrist to measure their pulse, presumably because the social encounter was novel or threatening for white men. In contrast, there were only minor fluctuations in heart rate during same-race encounters in men, and in same-race and different-race encounters in women. Perhaps cultural or social stereotypes associated with the experimenter accentuated cardiovascular responses in Siegman's studies or inhibited responses in the present study. Alternatively, the different effect sizes might be due to cultural differences between Israeli and North American men and the present sample of Chinese and Caucasian subjects. It is interesting to note that anger ratings were in the lower half of the scale in the present study but in the upper half of the scale in each of Siegman's studies when subjects described anger-provoking incidents loudly and rapidly (Siegman, 1993; Siegman et al., 1990; Siegman & Snow, 1997).

Cutaneous Blood Flow

Because blood flow decreases through most parts of the cutaneous circulation during psychological arousal, it was hypothesized that digital blood flow would decrease during anger expression. This hypothesis was confirmed, both when anger-provoking incidents were described loudly and rapidly or softly and slowly. Thus, the link between anger expression and digital vasoconstriction appeared to be stronger than the link between anger expression and blood pressure. Folkow (1982) postulated that frequent repetition of psychogenic pressor responses that increase the load on the heart and blood vessels may contribute to the development of hypertension. This hypothesis is supported by an association between cardiovascular disease and anger (Siegman, 1993), although some components of this association (e.g., defensiveness) might develop secondarily and do not necessarily involve the overt expression of anger (Jorgensen, Johnson, Kolodziej, & Schreer, 1996).

An increase in forehead pulse amplitude indicated that facial flushing developed when participants described anger-provoking incidents. Facial flushing is an active vasodilator response mediated by the sympathetic nervous system (Drummond, 1997b; Drummond & Finch, 1989; Drummond & Lance, 1987; Nordin, 1990) that might limit increases in blood pressure by lowering resistance to blood flow through the facial vascular bed (Drummond, 1999). The hypothesis that vasoconstriction would overrule facial flushing when anger was expressed loudly and quickly was not supported, possibly because most subjects felt only slightly angry during this procedure. Further investigation is required to identify the stimulus parameters for facial pallor during rage reactions.

Facial blood flow decreased when participants read out the neutral material, despite increases in ratings of embarrassment. This finding indicates that embarrassment does not always result in blushing; instead, facial blood vessels apparently constrict during minor emotional discomfort. More intense embarrassment (Drummond, 1997b) or anger (Drummond, 1999) triggers increases in facial blood flow, presumably mediated by active sympathetic vasodilatation or circulating catecholamines (Drummond, 1997b). In people with fair skin, facial reddening sends signals of social discomfort that may alter the behavior of others in the social encounter. Decreases in cranial temperature during facial blushing might also help to restore emotional equilibrium (Zajonc, Murphy, & Inglehart, 1989).

Conclusions

The present findings give qualified support to Siegman's (1993) notion that expressing anger verbally heightens the intensity of anger and physiological arousal. However, the metabolic requirements of speaking loudly and rapidly during anger expression also contribute substantially to physiological arousal. In accord with the James-Lange and cognitive theories of emotion, increases in physiological arousal when speaking loudly and rapidly may heighten the subjective experience of anger (Siegman & Snow, 1997). Simultaneously, however, certain physiological responses (e.g., facial flushing and possibly baroreflex-induced decreases in heart rate) could act homeostatically to limit cardiovascular reactivity, and thus might ultimately help to defuse anger.

A host of individual differences in psychological and physiological characteristics appear to influence how anger is experienced and expressed (Drummond, 1999). Our attempt to define race as one modifying influence was not successful, possibly because we did not draw strongly enough on cultural taboos. A more sophisticated approach involving manipulation of the perceived status or authority of the experimenter might prove to be more successful.

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