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Cardiovascular Responses of Embarrassment and Effects of Emotional Suppression in a Social Setting

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The cardiovascular effects of embarrassment and of attempts to suppress embarrassment were examined. In 2 studies, embarrassment was associated with substantial increases in systolic and diastolic blood pressure, which monotonically increased over a 2-minute embarrassment period. In contrast, heart rate (HR) rose significantly during the 1st minute of embarrassment but returned to baseline levels during the 2nd minute. This pattern of reactivity may be distinctive. The effects of trying to suppress emotion in an interpersonal situation were also tested. Relative to the no-suppression group, suppression participants showed greater blood pressure during embarrassment and during posttask recovery. Suppression did not significantly affect HR. Possible mechanisms for these results, including passive coping, are discussed. Nonverbal behavior was also examined.

It has been recently argued (Keltner, 1995; Keltner & Buswell, 1997; Miller, 1996) that embarrassment deserves a place on the modest-sized list of basic human emotions. Although the first ontogenetic manifestations of embarrassment appear later than do other basic emotions such as fear or anger (Buss, Iscoe, & Buss, 1979), embarrassment appears to be ubiquitous (Eibl-Eibesfeldt, 1972). Cross-cultural studies have found many similarities in the descriptions of embarrassment and its physical signs (Edelmann et al., 1989; Edelmann & Iwawaki, 1987). Attempts to avoid this "self-conscious" emotion may sometimes have severe consequences. For example, fear of embarrassment may play an important role in the lack of bystander intervention during ambiguous emergency situations (Latane & Darley, 1970). It also may contribute to certain forms of risky behavior, such as the failure to practice safe sex (Leary & Dobbins, 1983). Despite its ubiquity and potential importance, embarrassment remains a relatively unstudied emotion. In particular, aside from studies of blushing, there has been little work on the physiological state that accompanies embarrassment. This article examines cardiovascular responses during embarrassment and looks at how attempts to suppress embarrassment affect physiological reactivity.

A number of recent articles have suggested that when participants are asked to hide or suppress their emotional displays, they show greater responsivity on some psychophysiological measures, as compared with participants who are not attempting to suppress their emotions (Gross, 1998; Gross & Levenson, 1993, 1997; Richards & Gross, 1999). This pattern has been observed with respect to disgust, amusement, and sadness. Self-conscious emotions, including embarrassment or shame, have not been studied. Another important limitation of the existing work on suppression is that it has almost exclusively relied on studies that elicit emotion through films. No study to date has examined the physiological effects of emotional suppression in actual interpersonal contexts. The present research extends the literature by examining the psychophysiological effects of suppression while participants are embarrassed in front of a live audience. This seems particularly important given a recent study that found that reactivity associated with asocial stress did not predict reactivity during interpersonal conflict (Lassner, Matthews, & Stoney, 1994)

Embarrassment

Researchers studying embarrassment have focused on a variety of issues; some examples are the cognitive processes that engender embarrassment (Goffman, 1959; Miller & Tangney, 1994; Parrott & Smith, 1991), the social circumstances that affect embarrassment (Leary, Landel, & Patton, 1996; Parrott, Sabini, & Silver, 1988; Tangney, Miller, Flicker, & Barlow, 1996), and the ontogenetic development of embarrassment (Buss et al., 1979; Lewis, Stanger, Sullivan, & Barone, 1991) as well as individual and cultural differences in embarrassment (Cupach & Imahori, 1993; Edelmann et al., 1989; Sabini, Siepmann, Stein, & Meyerowitz, 2000). The present article only discusses in detail the literature that has focused on the behavioral displays and the physiological concomitants of embarrassment, as that is most germane to the focus of the present investigation. For more thorough overviews of the embarrassment literature, the reader is directed to Buss (1980), Edelmann (1987), and Miller (1996).

Several studies have focused on the nonverbal facial displays associated with embarrassment. When participants were asked to describe their typical reactions during an embarrassing episode, some of the behaviors most commonly reported included blushing, smiling, laughing, avoiding eye contact, and self-touching (Edelmann, 1987). Participants who were embarrassed by Edelmann and Hampson (1979, 1981) showed reduced eye contact and increased body movements and speech disturbances. Keltner (1995)

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performed detailed coding and analysis of the nonverbal behaviors that occur during embarrassment and found that the most robust features of the embarrassment display were frequent gaze shifts, looking down, attempts to control smiling, and touching the face. Asendorpf (1990) reported that gaze aversion during embarrassment occurs before the apex of the smile (when the corners of the mouth are maximally extended), whereas in humor gaze aversion occurs after the apex of the smile. Other studies have shown that observers can accurately identify the expression of embarrassment, particularly intense embarrassment, and can distinguish it from other emotional expressions, including shame (Keltner, 1995; Keltner & Buswell, 1996; Keltner, Young, & Buswell, 1997; Marcus & Miller, 1999).

Only a few studies have examined psychophysiological responses of embarrassment. Shearn and colleagues (Shearn, Bergman, Hill, Abel, & Hinds, 1990, 1992) have shown that cheek and ear coloration, measured with photoplethysmography, as well as cheek temperature and skin conductance increased more during an embarrassing video (watching oneself sing in front of an audience), as compared with a nonembarrassing emotional video (the shower murder scene in the film *Psycho*). Furthermore, the intensity of cheek coloration and electrodermal responses significantly increased when the size of the audience increased from one to four. An increase in electrodermal activity during embarrassment is also consistent with a study by Miller (1987), in which he elicited empathetic embarrassment by having observers watch someone with whom they had previously interacted engage in embarrassing acts. The observers' ratings of their own embarrassment were correlated with their electrodermal reactivity.

Aside from blushing, the cardiovascular effects of embarrassment remain virtually unstudied. People report believing that their heart rate increases when they are embarrassed (Edelmann, 1987; Edelmann et al., 1989). In contrast to these self-report studies, one early experiment (Buck, Parke, & Buck, 1970) found that anticipation of an embarrassing event (having to suck on infantile objects such as pacifiers) was associated with a decrease in heart rate. However, participants did not actually engage in the embarrassing act, so it is unclear whether they were indeed experiencing embarrassment. Therefore, it is unknown whether a similar pattern is associated with the embarrassment people experience while actually performing such acts. In short, although the nonverbal display of embarrassment has been well characterized, there is little known about the physiological state that accompanies embarrassment.

Emotion Regulation Through Suppression

The literature on the psychophysiological effects of emotional suppression has presented mixed findings. Early work suggested that suppressing emotional expressions might ameliorate some of the physiological reactivity that occurs during an emotional state. For example, Lanzetta, Cartwright-Smith, and Kleck (1976) found that when participants were asked to hide their expressions while receiving electrical shocks, they showed smaller electrodermal responses than when they were instructed to act naturally or to pose an intense expression.[1] Similar results also were reported by Colby, Lanzetta, and Kleck (1977). In another study, participants were asked to suppress, exaggerate, or spontaneously respond while watching pleasant and unpleasant films (Zuckerman, Klorman, Larrance, & Spiegel, 1981). Exaggeration led to greater reactivity on a composite index of heart rate, electrodermal activity, and blood volume, whereas suppression tended to cause smaller increases relative to spontaneous reactions (although the effect of suppression was not entirely consistent across physiological measures and film type). In a study of humor, suppression led to decreases in heart rate when the comic video included audience close-ups, but the opposite effect occurred in the absence of such dubbing (Bush, Barr, McHugo, & Lanzetta, 1989).

In contrast to earlier work, several recent articles by Gross and his colleagues have indicated that emotional suppression also can lead to enhanced physiological reactivity on at least some measures. Gross and Levenson (1993) asked half of their participants not to show their feelings while watching a film designed to elicit disgust. They then compared the responses of this suppression group with those of a control group on eight physiological measures. The results were mixed. Suppression led to heightened electrodermal responsivity and increased cardiovascular activation on some measures (e.g., finger pulse transmission and amplitude). However, suppression showed the opposite effect on heart rate and had no effect on other measures, such as finger temperature and respiration. In a second study, Gross (1998) used this same design to examine the effects of two forms of emotion regulation on four physiological measures. He found that suppression enhanced electrodermal activity and cardiovascular activation measured with pulse amplitude and finger temperature but did not significantly affect heart rate. In another study, instructions not to show any emotion during a sad film and an amusing film led to increases in sympathetic activation on a composite cardiovascular system measure that included measures such as pulse transit time and finger temperature but that excluded heart rate (Gross & Levenson, 1997). However, the effect of suppression on other physiological measures, such as electrodermal activity and respiration, produced mixed results across the two films. Most recently, suppression while participants looked at emotionally charged pictures of wounded men significantly increased systolic blood pressure (SBP), diastolic blood pressure (DBP), and finger temperature but not heart rate or electrodermal activity relative to a no-suppression condition (Richards & Gross, 1999).

In summarizing these findings, Gross (1998) and Gross and Levenson (1997) have suggested that some of the differential effects of suppression that have been observed across studies may be related to the specific type of emotion elicited. However, they noted that across most emotional situations that they have examined, emotional suppression has a palpable cost in terms of enhanced sympathetic activation of the cardiovascular system. The main exception to this pattern is heart rate, which has sometimes been found to be higher under no-suppression conditions. Gross and Levenson (1993, 1997) have proposed that participants who are not suppressing may engage in more somatic activity, which may be responsible for their heightened heart rate relative to that of suppressors.

[1] This effect occurred when participants thought that they were being observed and videotaped through a one-way mirror. Electrodermal responses did not differ in the two conditions when participants were led to believe that they were not being observed. Also, during no-shock trials, electrodermal activity was higher in the suppression group.

In general, the studies that have examined the effect of suppression on physiological indices have found no effects on self-reports of emotional intensity. However, there are some exceptions. Lanzetta et al. (1976) found that suppression led to lower self-reports of pain intensity during low and medium shock levels but not during high levels. Self-reports of amusement have been mixed (Bush et al., 1989; Gross & Levenson, 1997).

The Present Work

The present investigation addresses questions that span two relatively unexplored topics: embarrassment and emotion regulation through suppression. First, what are the cardiovascular concomitants of embarrassment? Recent work examining the nonverbal displays as well as the antecedent situations that give rise to embarrassment has suggested that embarrassment is a distinct primary emotion that can be distinguished from other emotions (Keltner, 1995; Miller & Tangney, 1994). Evidence has begun to accumulate suggesting that several other basic emotions, such as fear, anger, and disgust, are accompanied by different (although sometimes subtle) patterns of sympathetic nervous system (SNS) activity (see Levenson, 1992, for a review). This evidence is further explored in the General Discussion section. However, as noted above, little is known about the psychophysiological state that accompanies embarrassment. In the present work, continuous measures of SBP, DBP, and heart rate were taken during the elicitation of embarrassment.

The second primary question is whether cardiovascular effects of suppression can be found in an interpersonal context. As previously discussed, research on the effects of suppression on SNS activity have provided mixed results—under some circumstances suppression appears to lower reactivity, whereas in other cases it heightens reactivity. With the exception of studies of painful shocks, most of the work in this area has relied exclusively on emotion elicited by watching films or slides. Given these inconsistencies and the fact that many of our everyday emotional experiences are elicited in social settings, it seems important to examine the effects of suppression in interpersonal contexts. In the second study, participants were put in an embarrassing predicament in front of a live audience and were either asked to suppress their emotions or were not given such instructions. This work tested the effects of suppression on three cardiovascular indices: SBP, DBP, and heart rate. Gross (1998) has found that suppression effects continued for a 1-minute postfilm recovery period. However, no study has looked at recovery periods of longer lengths. The present work investigates the time course of suppression effects by continuously measuring reactivity for 5 minutes postembarrassment. Examining the cardiovascular effects of suppression seems particularly important given the widely held view that the repeated increases in SNS activity that accompany emotional experiences may be a potential risk factor in the development of coronary heart disease (Krantz & Manuck, 1984).

Study 1

Method

Participants

Twenty-one women and 13 men participated in exchange for partial fulfillment of course credit for a psychology class at the University of California, San Diego.

Procedures

On arriving at the site of the experiment, the participant signed a consent form. The female experimenter explained that the purpose of the study was to explore tasks that naturally vary in rhythm in order to determine how rhythmic versus staccatic style influences patterns of arousal. The blood pressure cuff was then placed on the participant's middle finger. During the first part of the experiment, the participant sang the lyrics to the "Star Spangled Banner" twice in front of a video camera and the experimenter. Past research has successfully used this manipulation to elicit embarrassment (Apsler, 1975; Miller, 1987; Shearn et al., 1990, 1992). The written lyrics were provided, and participants were instructed to look up at the camera as often as possible and to sing with feeling. After the singing portion of the experiment, to allow the physiological measures to return to baseline, participants were given 10 minutes to relax and read magazines.

The second part of the experiment began with participants relaxing alone for an additional 6 minutes while physiological baseline measures were taken. Participants were then given a questionnaire to fill out for 5 minutes while baseline measures were continuously recorded.[2] Next, the experimenter returned to the room with two confederates and told the participant that they were all going to watch the videotape of the participant singing and that the participant would be told more about this at the end of the experiment. While watching the video, the participant could see the faces of the experimenter and the two confederates, all of whom sat to the left side between the participant and the television (following Shearn et al., 1992). During the videotape viewing, the audience members kept pleasant smiles on their faces and glanced over at the participant twice. The participant was not given any instructions on how to respond while watching the videotape. After viewing the tape, the participant was left alone, and physiological measures were continuously recorded during a 5-minute recovery period. After the recovery period, participants filled out a questionnaire consisting of the self-report measures.

In sum, the experiment consisted of three experimental phases: a baseline period, the embarrassment task, and a recovery period.

Physiological Measures

SBP, DBP, and heart rate were measured using an Ohmeda Finapres 2300 Blood Pressure Monitor (Ohmeda, Columbia, MD). This noninvasive device employs the Penaz method to take beat-to-beat readings using a small finger cuff and has been shown to provide good tracking of intra-arterial readings (e.g., see Parati, Casadei, Groppelli, DiRienzo, & Mancia, 1989).

Self-Report Measures

After watching the video, participants used a 9-point scale (1 = *not at all*, 9 = *very*) to rate how much they had felt each of the following: anxious, happy, fearful, amused, nervous, angry, and calm. Participants rated their embarrassment using a 9-point, four-item scale designed by Modigliani (1971). In addition, participants were asked the following written open-ended question: "What emotion term would best describe how you felt when everyone was watching you sing on the video?"

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[2] The average response during the second 5-minute part of the baseline was used in all statistical analyses, instead of the resting baseline, and is similar to a "vanilla baseline" in which participants do a low-level cognitive task (Jennings, Kamarck, Stewart, Eddy, Johnson, 1992). The questionnaire consisted of various demographic inquiries. This type of baseline was included in this study because of an additional manipulation that was performed at the end of the experiment. The final manipulation attempted to examine the effects of rumination versus distraction on the reactivity associated with recall of emotion. No effects were found, and therefore these data are not presented. Using the resting baseline for the present analyses does not significantly alter any of the findings or conclusions.

Results

No gender differences were found except where noted; therefore, analyses are collapsed across this factor.

Effects of Embarrassment on Cardiovascular Reactivity

Values from the 5-minute baseline period were averaged together to form one baseline score for each physiological measure. Mean levels for SBP and DBP are presented in Figure 1. To examine the effect of embarrassment on cardiovascular activity, I performed two comparisons for each physiological measure: (a) baseline levels versus levels at Minute 1 of embarrassment, and (b) levels at Minute 1 of embarrassment versus levels at Minute 2. A paired *t* test revealed that SBP levels were significantly greater during the 1st minute of the embarrassment period relative to baseline levels, $t(33) = 7.90$, $p < .0001$. SBP levels during Minute 2 were also significantly greater than levels during Minute 1 of the embarrassment period, $t(33) = 4.42$, $p < .0001$, suggesting that SBP continued to rise as the embarrassing situation continued. Embarrassment had similar effects on DBP. During Minute 1 of embarrassment, DBP levels were significantly greater than baseline levels, $t(33) = 8.27$, $p < .0001$, and DBP continued to rise, with levels at Minute 2 of embarrassment significantly greater than levels at Minute 1, $t(33) = 5.16$, $p < .0001$.

As with SBP and DBP, heart rate significantly increased during the 1st minute of the embarrassment manipulation relative to baseline, $t(33) = 3.13$, $p < .004$. However, unlike blood pressure, heart rate levels during Minute 2 of embarrassment were significantly lower than levels during Minute 1, $t(33) = 5.63$, $p < .0001$. During this 2nd minute of embarrassment, heart rate had dropped to a level that was statistically indistinguishable from baseline levels (see Figure 2).

Cardiovascular Recovery After Embarrassment

The next set of analyses examined whether the elevated SBP and DBP levels produced during the embarrassment task continued throughout the 5-minute recovery period. To assess recovery, I used paired *t* tests to compare levels during the 5th minute of recovery with baseline levels. At 5 minutes after the embarrassment manipulation, SBP levels remained significantly elevated over baseline levels, $t(33) = 3.26$, $p < .003$, as did DBP levels, $t(33) = 4.96$, $p < .0001$. Heart rate was not significantly elevated during recovery.

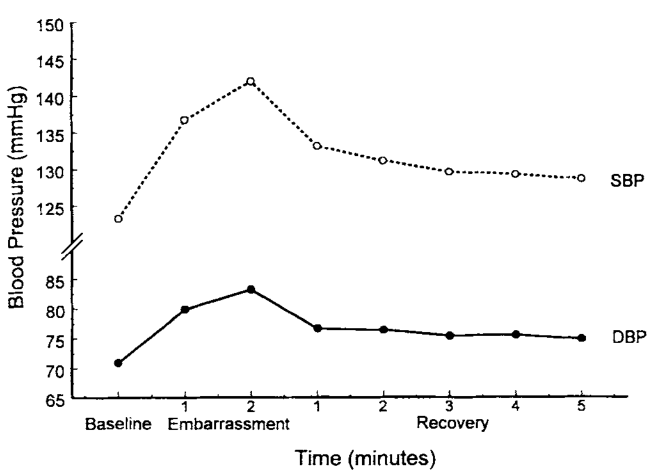

Figure 1. Systolic and diastolic blood pressure (SBP and DBP, respectively) levels for embarrassment and recovery periods during Study 1. mmHg = milligrams of mercury.

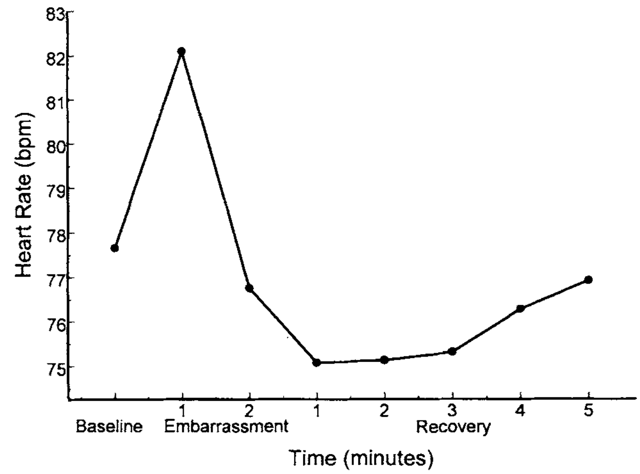

Figure 2. Heart rate levels for embarrassment and recovery periods during Study 1. bpm = beats per minute.

Self-Report Measures

Correlational analyses were performed comparing the changes in blood pressure and heart rate during the embarrassing situation with self-report ratings on each of the eight emotion terms.[3] In keeping with Modigliani (1971), the four ratings on the embarrassment scale were averaged together to form one index of self-reported embarrassment (Cronbach's $\alpha = .67$). SBP and DBP scores were not significantly correlated with any of the self-report ratings. However, changes in heart rate during Minute 1 of the embarrassing situation were significantly correlated with ratings of embarrassment, $r(34) = .38$, $p < .03$. Heart rate was not significantly associated with ratings on any other emotion term.[4]

The open-ended question asking people to label their emotional state was coded using the classification system of Keltner (1995), supplemented by the terms described by Modigliani (1968) as defining embarrassment. Fifty-three percent of the participants described their emotional state as embarrassment (or used a closely related term—e.g., awkward, silly, stupid, self-conscious). The second most common term, used by 6 individuals, was *funny/amused*. The remaining descriptions were heterogeneous, and many were not emotion terms but described states that are intuitively consistent with embarrassment (e.g., weird, shy, "just felt it will all be over soon"). When I examined the physiological data from just those participants who used the term *embarrassed* or a

[3] The amusement question was inadvertently left off the questionnaire given to the first 8 participants.

[4] However, it should be noted that additional analysis failed to show that the correlation between heart rate and embarrassment was significantly greater than the next largest correlation, which was between heart rate and anxiety, $r = .20$.

synonym, I obtained results identical to those described for the sample at large.

Discussion

This study appears to be the first to measure continuous changes that occur in heart rate and blood pressure when participants are actively experiencing an embarrassing event. Embarrassment was associated with a significant increase in blood pressure. Both SBP and DBP rose significantly during the 1st minute of embarrassment and continued to rise substantially during the 2nd minute (with an average increase of 16 mm for SBP and 10 mm for DBP). These increases are striking and similar in magnitude to those commonly found in studies that actively elicit emotions such as anger and fear: for example, studies that have participants engage in public speaking or perform serial subtraction during harassment (e.g., Suarez & Williams, 1989; Turner, 1994). This is noteworthy because in these other types of studies, participants are also concurrently speaking or engaging in other cognitive tasks, which independently raise blood pressure. In our study, by contrast, participants were simply sitting. Moreover, the recovery from these elevated levels was not rapid. Participants' blood pressure still had not returned to baseline levels even after they sat alone for 5 minutes after the embarrassing situation. Heart rate changes presented a different pattern than did blood pressure changes. Rather than continuing to increase, heart rate rose significantly during the 1st minute of embarrassment but dropped back to baseline levels during the 2nd minute. This pattern of reactivity is explored further in the General Discussion section.

It is interesting that self-report ratings of degree of embarrassment were correlated with heart rate changes. The one study that previously measured heart rate found that it decreased while participants were anticipating an embarrassing event (Buck, Parke, & Buck, 1970). However, in studies by Edelmann and colleagues (Edelmann et al., 1989), most people reported that their heart rate increased during embarrassment. The present work suggests that embarrassment leads to a brief but distinct increase in heart rate. Awareness of this initial increase may be what fuels people's self-reports.

The second study has two goals. The first is to attempt to replicate the cardiovascular pattern found for embarrassment in Study 1. The second goal is to examine the effect of one form of emotion regulation, suppression, on cardiovascular reactivity in an interpersonal situation.

Study 2

Method

Participants

Twenty-one women and 15 men participated in exchange for partial fulfillment of course credit for a psychology class at the University of California, San Diego.

Procedures

Participants, who attended individual sessions, were randomly assigned to one of two conditions (suppression or no-suppression). The procedures and measures were the same as those used in Study 1, except as noted. The instructions given in Study 1 also were given in the present study. However, participants in the suppression group were given the following additional instructions for viewing the video: "While we watch the video, please do not display any emotional reaction. Behave so that if they look at you they won't be able to tell what you are feeling." To keep the two confederates unaware of the condition, the experimenter gave the instructions regarding watching the videotape to the participant immediately before the audience entered the experimental room.

While they were watching the videotape of themselves, participants' facial behavior and upper body movements were taped by a video recorder that was placed next to the monitor on which they watched themselves sing.

Physiological Measures

SBP, DBP, and heart rate were measured as in Study 1.

Self-Report Measures

The same self-report measures as in Study 1 were used in the present work.

Behavioral Measures

Participants' nonverbal behavioral responses were coded using a system designed for this study and loosely based on the Facial Action Coding system (Ekman & Friesen, 1978) that was used by Keltner (1995) in previous studies of embarrassment. A total of seven behavioral categories were examined. Frequency and duration were coded for gaze activity (including direction), smiling, attempts at controlling smiling, and face touching, all of which have been shown to be associated with embarrassment (Keltner, 1995). Duration was coded in seconds; it began at the first indication of the behavior and ended at the last sign of the behavior. Frequency of behavior from three additional categories (body movement, blinking, and swallowing) was also coded because of the potential relevance for suppression (Gross & Levenson, 1993).

Two raters who were unaware of participants' experimental condition coded the videotapes of the participants' behavior while they watched themselves sing. Ten participants (5 from each condition) were randomly selected and coded independently by both raters. Interrater reliability was high across all categories of behavior, ranging from .85 (frequency of body movements) to .99 (duration of face touching). Differences in coding were resolved by taking the average of the two raters' codes.

Results

The analytical procedures in the present investigation followed the recommendations of Huberty and Morris (1989) with regard to the use of univariate analyses of variance (ANOVAs) versus multivariate analyses of variance (MANOVA).

Physiological Measures

Effects of embarrassment on cardiovascular reactivity. The goal of the first analysis was to determine whether the physiological effects of embarrassment found in Study 1 were replicated. Suppression participants were excluded from these analyses, as suppression was hypothesized to affect reactivity. Paired one-tailed t tests confirmed the findings of Study 1.

During Minute 1 of the embarrassment manipulation, SBP levels, $t(17) = 5.68$, $p < .0001$, were significantly elevated from baseline levels. SBP continued to rise, as levels during Minute 2 of embarrassment were significantly greater than during Minute 1, $t(17) = 1.98$, $p < .04$, for SBP. DBP showed the same pattern as

SBP, with levels at Minute 1 significantly greater than baseline, $t(17) = 6.66$, $p < .0001$, and levels at Minute 2 significantly greater than at Minute 1, $t(17) = 3.75$, $p < .001$. The results for heart rate also confirmed those found in Study 1. During Minute 1 of embarrassment, heart rate level was significantly greater than at baseline, $t(17) = 2.23$, $p < .02$. However, heart rate levels had significantly decreased during Minute 2 of embarrassment relative to Minute 1 levels, $t(17) = 4.59$, $p < .0001$, and were not significantly different from baseline levels.

Cardiovascular recovery after embarrassment. The next analyses again focused on the participants from the no-suppression group to examine cardiovascular recovery from embarrassment. As in Study 1, both SBP and DBP levels still had not returned to baseline levels at 5 minutes posttask, $t(17) = 2.59$, $p < .01$, and $t(17) = 3.90$, $p < .001$, respectively. These results suggest not only that blood pressure increased while participants experienced the embarrassing situation but also that blood pressure levels remained significantly elevated even 5 minutes after the embarrassing situation had ended and the audience had departed.

Tests for baseline differences. To ensure that the suppression and no-suppression groups did not significantly differ on any of three physiological measures before the suppression manipulation, I performed t tests on the baselines of each of the physiological measures. Resting baseline for the two groups was virtually identical ($t < 0.16$) for SBP (no-suppression = 121.2, and suppression = 122.1) and DBP (no-suppression = 67.9, and suppression = 67.3).[5] Heart rate was slightly higher in the no-suppression group ($M = 79.1$ vs. 74.9), but this difference was not statistically significant, $t(34) = 1.56$, $p = .13$.

Because of the between-subjects factor, in subsequent analyses raw baseline levels are used as a covariate.

Effects of suppression on physiological measures during embarrassment. A between-subjects (suppression vs. no suppression) analysis of covariance (ANCOVA) was conducted on the average SBP level during the 2-minute embarrassment period with baseline level as a covariate.[6] This revealed a significant effect of suppression, such that suppression led to greater SBP increases, $F(1, 33) = 7.30$, $p < .02$. Follow-up ANCOVAs examined the minute-by-minute effect of suppression during the embarrassing situation. Adjusted mean levels are presented in Figure 3. Although there was a marginal effect of suppression during the 1st minute of embarrassment, $F(1, 33) = 3.48$, $p = .07$, this effect became much more pronounced during the 2nd minute of suppression, $F(1, 33) = 7.68$, $p < .01$. This suggests that as time goes by, the physiological consequences of actively suppressing one's emotions become more pronounced.

Analyses of DBP revealed a pattern of results similar to that found with SBP. A between-subjects ANCOVA was conducted on average DBP level during the 2-minute embarrassment period with baseline DBP level as a covariate, revealing a trend toward suppression increasing DBP more than did not suppressing, $F(1, 33) = 3.17$, $p = .08$. Follow-up ANCOVAs examined each minute of the embarrassment period and revealed that, as with SBP, the effect of suppression on DBP became more pronounced over time, $F(1, 33) = 4.46$, $p < .05$, for the 2nd minute of embarrassment, and $F(1, 33) = 1.36$, $p = .25$, for the 1st minute of embarrassment.

Adjusted means for heart rate are presented in Figure 4. An ANCOVA was conducted on the average heart rate level during the 2-minute embarrassment period with baseline heart rate level as a covariate, $F(1,33) = 1.18$, *ns*. As in previous research (e.g., Gross, 1998), suppression did not have a significant effect on heart rate. (Separate analyses of each minute of embarrassment also did not reveal an effect of suppression on heart rate.)

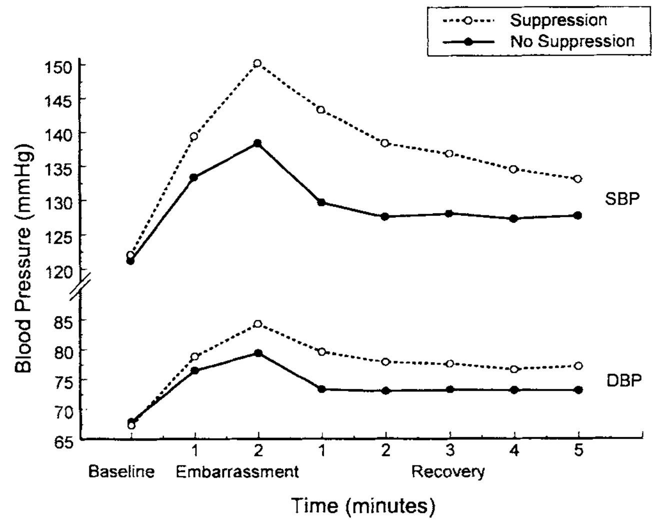

Figure 3. Adjusted mean levels of systolic and diastolic blood pressure (SBP and DBP, respectively) during embarrassment and recovery periods for suppression and no-suppression groups in Study 2. mmHg = millimeters of mercury.

Effects of suppression on physiological measures during recovery. The next set of analyses examined whether the cardiovascular effects of suppression continued during the recovery period. With baseline SBP levels as a covariate, an ANCOVA with suppression condition as a between-subjects factor was performed on the average SBP level during the 5-minute recovery period. The suppression participants had significantly greater SBP levels during the recovery period, $F(1, 33) = 5.69$, $p < .03$. These results suggest not only that suppression significantly increased blood pressure reactivity during embarrassment but also that these effects continued even after the emotion-eliciting stimulus was gone. To explore how long the effects of suppression lasted, I performed follow-up ANCOVAs on each minute of recovery. These analyses revealed that relative to the no-suppression group, the suppression group still had significantly elevated SBP until the 4th minute of recovery; this finding replicates and extends work by Gross and Levenson (1993) and Gross (1998).

Similar analyses were performed on DBP. An ANCOVA with average baseline DBP as a covariate was performed on the average DBP level during the 5-minute recovery period. This analysis revealed a significant effect of suppression on DBP recovery levels, $F(1, 33) = 4.73$, $p < .04$. Follow-up ANCOVAs examining each minute of recovery revealed that DBP levels were significantly greater in the suppression group until the 4th minute of recovery.

[5] Gender analyses revealed that the SBP and DBP resting baselines of men were significantly higher than those of women. Gender was evenly distributed over the suppression condition.

[6] Additional analyses indicated that homogeneity of variance assumptions was not violated in any of the ANCOVAs.

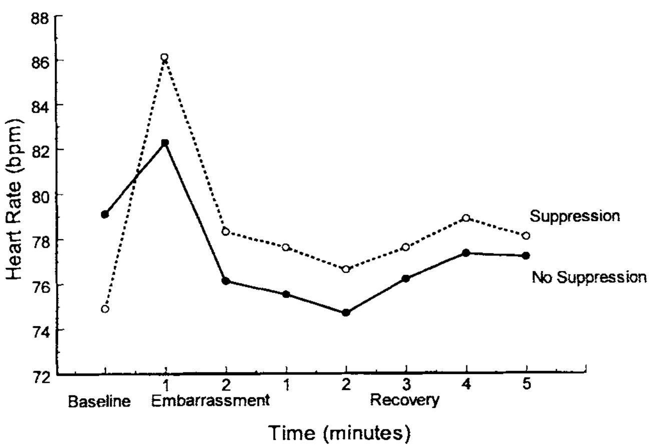

Figure 4. Adjusted mean heart rate during embarrassment and recovery periods for suppression and no-suppression groups in Study 2. bpm = beats per minute.

There were no significant effects of suppression on the average heart rate level during the 5-minute recovery period, $F(1, 33) = 1.27$, *ns*, nor at any individual time point during recovery.

Behavioral Measures

The nonverbal behavioral categories that were coded included both uninhibited emotional expression and attempts at emotional controls. It was anticipated that emotional suppression would have different effects on these different categories, and therefore separate MANOVAs or ANOVAs were conducted for each behavioral category. (The present data set meets the criteria laid out by Huberty & Morris, 1989, for application of this procedure.) Means on the behavioral measures are presented in Figure 5.

General body movements. To ensure that the cardiovascular differences between the two groups were not simply due to differences in somatic activity, coders recorded frequency of movements (e.g., playing with hair, biting fingernails, stretching). There was no hint of any difference between the suppression and no-suppression groups, $F(1, 34) = 0.01$, *ns*.

Previous work has reported that suppression causes people to touch their face less frequently (Gross & Levenson, 1993), whereas embarrassment leads people to touch their faces more frequently (Keltner, 1995). Therefore, I specifically assessed the effect of suppression of embarrassment on the frequency (not included in the previous analysis) and duration of participants' touching or covering their faces. The analysis of frequency of face touches did not show a significant difference for the two groups, $F(1, 34) = 2.34$, $p = .14$. However, suppression participants touched their faces for significantly shorter durations, $F(1, 34) = 6.59$, $p < .02$.

Smiles and laughter. The suppression group smiled and laughed less frequently than did the no-suppression group, $F(1, 34) = 4.25$, $p < .05$, and smiled for significantly shorter durations, $F(1, 34) = 5.77$, $p < .03$. Laughter duration was not coded.

Smile controls. Keltner (1995) has shown that embarrassed participants frequently engage in "smile controls," lower facial movements that tend to counteract or obscure a smile. Suppression instructions did not significantly alter the number of smile controls produced by participants, $F(1, 34) = 2.09$, $p = .16$. However, there was a trend toward suppression participants engaging in smile controls of longer duration, $F(1, 34) = 2.83$, $p = .10$.

Gaze activity. A 2 (suppression vs. no suppression) × 6 (direction of gaze shift) mixed ANOVA examined the number of gaze shifts. There was a significant effect of gaze direction, $F(5, 170) = 49.23$, $p < .001$. Follow-up Bonferroni corrected analyses revealed that as in previous research, embarrassed participants had significantly more gaze shifts downward than in any other direction (i.e., left, right, up, toward the camera, or toward the audience). Suppression instructions did not significantly affect the total number of gaze shifts or interact with direction of gaze shift ($F < 1$).

Analyses of duration of gaze shifts, collapsed across direction, revealed that the suppression group ($M = 78.5$ s, $SD = 29.7$) shifted their gaze for significantly longer periods of time than did the no-suppression group ($M = 52.0$ s, $SD = 36.6$), $F(1, 34) = 5.71$, $p < .03$. More specifically, suppression participants tended to gaze downward for longer durations ($M = 61.9$) than did no-suppression participants ($M = 40.9$), $F(1, 34) = 2.83$, $p = .10$.

Swallowing. An additional behavior, frequency of swallowing, which has not been examined in previous work, was also assessed. One common effect of increased emotionality is a dry

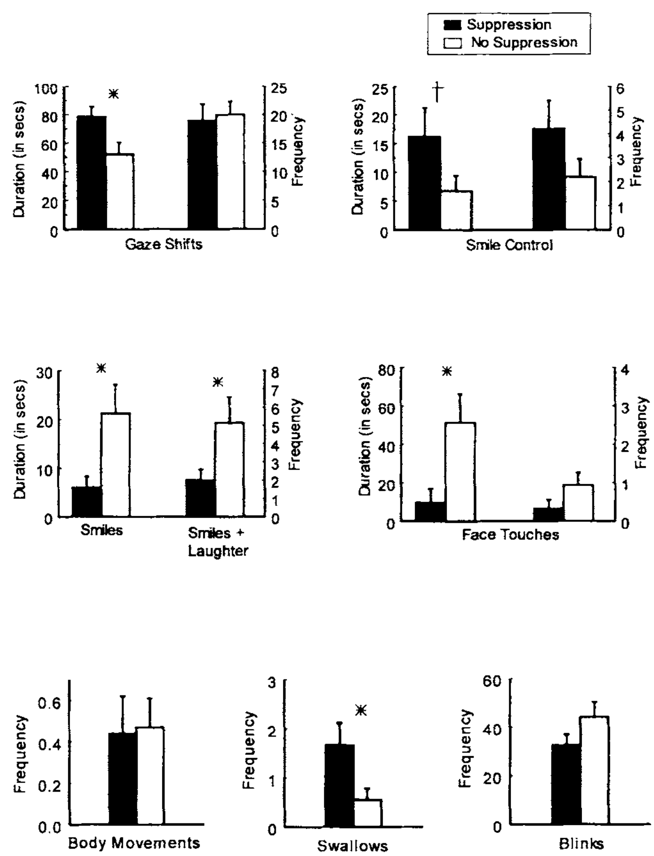

Figure 5. Mean duration and frequency of nonverbal behavior for suppression and no-suppression groups (with standard error of the mean). secs = seconds. †$p = .10$. *$p < .05$.

mouth produced by enhanced activation of the sympathetic nervous system. Increased emotional arousal has been shown to increase spontaneous swallowing (Fonagy & Calloway, 1986). Therefore, number of swallows was coded as an additional measure of increased emotionality in suppression participants. The suppression group showed more frequent swallowing than did the no-suppression group, $F(1, 34) = 4.85$, $p < .04$.

Blinking. The two groups did not significantly differ in frequency of blinking, $F(1, 34) = 2.40$, $p = .13$.

Correlations between nonverbal behavior and physiological measures. Duration of face touching tended to be negatively correlated with SBP levels during the embarrassing situation, $r(36) = -.30$, $p = .07$, during Minute 1, and $r(36) = -.43$, $p < .01$, during Minute 2. Rate of blinking was significantly correlated with DBP levels, $r(36) = .42$, $p < .02$, during Minute 1, and $r(36) = .37$, $p < .03$, during Minute 2.[7]

Self-Report Measures

Previous research by Gross and his colleagues (Gross, 1998; Gross & Levenson, 1993; Richards & Gross, 1999) has suggested that attempting to suppress an emotion does not alter the subjective experience of the emotion but affects emotional behavior and physiology. The next analyses examined participants' ratings of their emotional state. Four ratings on the Modigliani (1971) embarrassment scale showed high internal consistency (Cronbach's $\alpha = .83$) and were therefore averaged together to form one index of self-reported embarrassment. An overall MANOVA with suppression condition as a between-subjects factor was then performed on the self-report ratings for the eight individual emotion terms (including the embarrassment index). There was no significant effect of condition on the emotion terms as a whole (Wilk's $\lambda = 0.84$), $F(8, 27) = 0.63$, *ns*. Because the overall MANOVA was not significant, follow-up univariate analyses were not performed for the individual emotion terms. However, one planned comparison of the embarrassment ratings was performed, but it did not reveal an effect of suppression, $t(34) = 0.16$, *ns* ($M = 6.5$, $SD = 1.6$, for suppression; $M = 6.6$, $SD = 1.4$, for no suppression).

Correlational analyses were performed comparing the changes in blood pressure and heart rate during the embarrassing situation with self-report ratings on each of the eight emotion terms. SBP and DBP scores were not significantly correlated with any of the self-report ratings. As in Study 1, changes in heart rate during Minute 1 of the embarrassing situation were significantly correlated with self-report ratings of embarrassment, $r(36) = .37$, $p < .03$, and not significantly correlated with ratings on any other emotion term, with the exception of calmness ratings, which were negatively correlated with heart rate, $r(36) = -.43$, $p < .01$.[8]

Self-report ratings of embarrassment were not significantly correlated with any of the measures of nonverbal behavior.

The emotion terms provided by participants in their responses to the open-ended question were also analyzed. Suppression instructions did not affect participants' labels for their emotional states: Sixty-one percent of the participants from each condition used the term *embarrassed* or a synonym to describe their emotional state.

Discussion

Study 2 replicated the psychophysiological findings from Study 1. Embarrassment was associated with a substantial increase in blood pressure, which continued to rise while the embarrassing situation unfolded and remained significantly elevated even at 5 minutes postembarrassment. In contrast to blood pressure, heart rate rose significantly during the 1st minute of embarrassment but dropped back down to pretask levels during the 2nd minute of the embarrassing situation.

Attempting to suppress one's emotion in front of a live audience had pronounced effects on cardiovascular reactivity. SBP and DBP were significantly elevated in the suppression group relative to the no-suppression group. For example, the suppression group had, on average, a 67% greater increase in SBP and a 38% greater increase in DBP. This enhanced blood pressure reactivity continued even when the embarrassing video had stopped, the audience had left, and the participant sat alone. There was also a slight hint that heart rate, particularly in Minute 1 of embarrassment, might be more elevated in the suppression group, although this trend was not statistically significant. In sum, suppression generally appeared to have intensified the pattern of reactivity elicited by embarrassment under no-suppression conditions.

Suppression, although it decreased some of the most overt emotional signs, enhanced some of the other nonverbal displays of embarrassment. As one would predict, participants who were told to hide their feelings produced significantly fewer smiles and laughs and tended to spend more time trying to suppress their smiling than did participants who were not given such instructions. Suppression also had several other interesting effects on nonverbal behavior. Participants who were asked to hide their feelings spent significantly less time watching themselves on the video and tended to cast their gaze down more than did the no-suppression group. Previous work suggests that suppression and embarrassment may have different effects on frequency of face touching (specifically, that suppression decreases touching, whereas embarrassment increases it). When the two were pitted against one another in the present experiment, suppression did not significantly alter the number of times participants touched their faces. However, it did lead participants to engage in such behavior for significantly shorter durations. Suppression also led to more swallowing, which may have been a response to a dry mouth caused by greater autonomic arousal. This fairly easily observed behavior might be a useful cue to observers that someone is experiencing an emotional state but trying to not show it.

[7] The nonverbal displays of participants in Study 1 were coded as in the present study, and correlational analyses then were performed between nonverbal and physiological measures. Only results that replicated across the two studies are reported. In Study 1, duration of face touching negatively correlated with SBP, $r(31) = -.40$, $p < .03$, during Minute 1, and $r(31) = -.39$, $p < .04$, during Minute 2. The number of blinks correlated with DBP, $r(31) = .55$, $p < .01$, during Minute 1, and $r(31) = .60$, $p < .001$, during Minute 2.

[8] However, additional analysis failed to show that the correlation between heart rate and embarrassment was significantly greater than the next largest correlation, which was between heart rate and anxiety, $r = .30$.

Consistent with most previous work in this area, instructions to hide one's feelings did not significantly alter people's self-reports of the intensity of their emotional reaction.

General Discussion

This investigation assessed the cardiovascular indices of embarrassment and the effects of one form of emotion regulation, suppression, on cardiovascular reactivity in a social setting.

Cardiovascular Indices of Embarrassment

This is one of the first investigations to examine the cardiovascular consequences of embarrassment. A particular strength of these studies is their use of a continuous measure of both SBP and DBP as well as beat-to-beat readings of heart rate while the embarrassing situation unfolded. This revealed a unique pattern of reactivity for embarrassment that might otherwise have been obscured: SBP and DBP increased during the 1st minute of embarrassment and continued to rise during the 2nd minute. Heart rate, on the other hand, showed a small increase during the 1st minute but decreased to baseline levels during the 2nd minute of embarrassment. The debate about whether different emotional states are accompanied by different patterns of autonomic arousal has raged for more than a century, and comparing patterns of reactivity for different emotions across different studies can be treacherous. However, it is worth briefly discussing how the present work compares to findings in the literature that have been offered in support of autonomic specificity.

Although not all studies have found evidence of autonomic specificity for different emotions, Levenson (1992), reviewing his own work as well as that of others, argued that for a limited set of emotions there is evidence of subtle differences in autonomic activity. This conclusion is based on studies that have used a variety of different tasks, including posing facial expressions (Levenson, Ekman, & Friesen, 1990; Levenson, Ekman, Heider, & Friesen, 1992), reliving emotions (Levenson, Carstensen, Friesen, & Ekman, 1991; Schwartz, Weinberger, & Singer, 1981) and viewing emotional slides (Hare, 1973). Among negative emotions, heart rate accelerates during anger, fear, and sadness, whereas it appears either to decelerate or not to change during disgust (Levenson et al., 1990, 1991; Schwartz et al., 1981). As mentioned in the introduction, the one previous study that attempted to measure the heart rate activity associated with embarrassment found a decrease in heart rate while participants were anticipating an embarrassing event (Buck et al., 1970). Given this finding, one might have predicted that heart rate changes during embarrassment would be similar to those during disgust and unlike those during anger, fear, or sadness. The present results suggest that a heart rate increase followed by a rapid decrease may conceivably be a unique marker of embarrassment. Levenson (1992) has proposed that the decrease of heart rate during disgust may be due to parasympathetic activation. It may be the case that the physiological state experienced during embarrassment entails the activation of aspects of both the parasympathetic and the sympathetic branches of the autonomic nervous system.

SBP and DBP generally increase during anger, fear, and sadness, and there is some evidence to suggest that DBP increases are greater during anger (Roberts & Weerts, 1982; Schwartz et al., 1981). We cannot directly compare the blood pressure increases found for embarrassment in the present study with those found for anger and fear in other studies. However, in general, blood pressure and heart rate tend to covary in these other emotional states. For example, Schwartz et al. (1981) had participants imagine different emotions for 2 minutes. At the end of the imagery, SBP, DBP, and heart rate were all elevated in anger, in fear, and in happiness. In contrast, the present work found a decoupling of blood pressure and heart rate after 2 minutes of embarrassment. These data suggest that just as there is a distinctive nonverbal display of embarrassment, there also may be a signature pattern of cardiovascular reactivity.

An uncoupling of physiological measures over time is also found in another common feature of embarrassment, namely, blushing. Work by Shearn and colleagues (1990, 1992) found that peak coloration of the cheek and peak temperature of the cheek were not synchronized during an embarrassment manipulation similar to the one used in the present work. This research as well as that of others (Drummond, 1997; Drummond & Lance, 1987) suggests that the phenomenon of blushing begins with a sharp increase of blood flow, which is then followed by a slower rise in facial temperature. Shearn et al. (1990) proposed that this decoupling of the two responses is due to activation of separate mechanisms and suggested that "the perception of one's own blushing is the detection of a rise in facial temperature, and not the more immediate blood flow or volume responses which are scarcely detectable [to oneself]" (p. 691). Yet blood volume is likely responsible for the actual appearance of blushing.[9] Shearn et al. drew the intriguing implication that others may be able to detect our blushing before we are aware of it ourselves. Other nonverbal displays of embarrassment also appear to unfold in a unique way over time. Keltner (1995) has shown that a typical expression begins with a downward gaze, followed by a smile control or smile and then a gaze shift and head turn.

In sum, embarrassment is a fundamentally social emotion that appears to be accompanied by a distinct set of autonomic and behavioral concomitants. Compared with other basic emotions such as fear and anger (which can be elicited by social and nonsocial stimuli), these indices appear quite complex, unfolding in a distinctive fashion over time.

Effects of Suppression

The present work found that trying to suppress one's emotional response to an embarrassing situation led to significantly greater increases in both SBP and DBP relative to a no-suppression condition. Moreover, the effect of suppression on blood pressure seems to become stronger the longer one attempts to suppress (i.e., the suppression effects during Minute 2 of embarrassment were more pronounced than those during Minute 1), suggesting that the

[9] Two additional points regarding blushing should be noted. First, although blushing frequently accompanies embarrassment, it does not always do so and also can occur without reported embarrassment (see Leary, Britt, Cutlip, & Templeton, 1992, for a complete review of blushing). Second, the physiological mechanisms responsible for blushing are not well understood. Recent work by Drummond (1997, 1999) suggests that several mechanisms most likely play a role in blushing and that facial beta-adrenergic receptors of the SNS appear to be one such mechanism.

longer one tries to hide one's feelings, the more demanding it becomes physiologically to do so. Although the present work looked at suppression effects over a longer duration than did most previous studies, it still only examined effects over a relatively short period. Given that many of our emotional interactions outside the laboratory occur over longer durations, it would be interesting in future work to examine how suppression affects physiology over even longer periods.

The present results are consistent with several findings from the literature. Richards and Gross (1999), who used measures comparable to those in the present work, also found significant increases in SBP and DBP when participants suppressed their reactions to emotionally disturbing pictures. The current results are also in keeping with the finding that suppression leads to greater decreases in pulse amplitude during disgust (Gross, 1998; Gross & Levenson, 1993) and to greater increases on a composite measure of sympathetic activation of the cardiovascular system (excluding heart rate) during amusement and sadness (Gross & Levenson, 1997). The present findings extend the literature by showing that the effects of suppression on blood pressure remained evident several minutes after the emotion-inducing situation had ended. In contrast to the effects on blood pressure, suppression had little effect on heart rate.

Why might emotional suppression have different effects on heart rate as compared with other cardiovascular indices, such as blood pressure? In previous studies, relative to no-suppression conditions, emotional suppression either had no effect on heart rate or lowered it while appearing to enhance other measures of cardiovascular reactivity. Gross and Levenson (1993, 1997) have suggested that the decreases in heart rate may be the result of a reduction in somatic behavior. The present work offers some support for this possibility. Although the suppression and no-suppression groups differed in facial expressivity, they did not differ in amount of general motor activity. Perhaps as a consequence of that, no-suppression participants failed to show greater heart rate reactivity than suppression participants, in contrast to earlier research. If anything, the suppression group had a nonsignificant tendency toward accelerated heart rates in the present work.

There are, however, other possible accounts for the decoupling of heart rate and blood pressure. One possibility is that suppression might exert its vascular effects primarily through alpha-adrenergic receptors. It has been proposed (Alquist, 1976) that catecholamines such as epinephrine and norephineprine activate the SNS by binding to two types of adrenergic receptors, alpha and beta. Whereas beta-adrenergic receptors appear to exist in both the vasculature and the heart, alpha-adrenergic receptors appear confined to the vasculature. Stimulation of these alpha receptors leads to vasoconstriction, which can result in increased blood pressure (Turner, 1994).

In the field of behavioral medicine, hemodynamic response patterns have begun to receive increasing attention in studies exploring the varied effects of different tasks on reactivity (Sherwood, Dolan, & Light, 1990; Turner, 1994). Most of the tasks used in this field are "stressful" tasks that elicit an unspecified negative emotional state (e.g., reaction time tasks or math carried out during harassment) and generally result in parallel increases in SBP, DBP, and heart rate. These increases are thought to be mediated by both cardiac and vascular beta-adrenergic receptors (Sherwood & Turner, 1992). However, there is one task—the cold press, which involves keeping a limb in extremely cold water—that tends to increase blood pressure without comparably increasing heart rate (Sherwood & Turner, 1992; Turner, 1994). This pattern of reactivity is believed to result primarily from stimulation of the alpha receptors alone, causing vasoconstriction. A more psychological analysis of the effects of these tasks is that the former tasks invoke active coping processes, whereas the cold press triggers passive coping (Obrist, 1981; Obrist et al., 1978). Obrist and colleagues have suggested that active coping occurs when a person believes that there is a potential to influence the outcome of an event, whereas passive coping occurs when an individual lacks the means to influence the outcome of an event (see Hartley, Ginsburg, & Heffner, 1999, for further data consistent with this hypothesis). Emotional suppression, like coping with inescapable pain, may best be characterized as a passive mode of emotion regulation, which may possibly result primarily in an alpha-adrenergic-activated hemodynamic pattern. Future work can help to determine the merit of this possibility by measuring cardiac output and vascular resistance.

The reader might recall that some of the early studies discussed in the introduction examined suppression under painful stimulation (electric shock) and failed to find an enhancement of SNS arousal due to suppression. However, this early work did not examine blood pressure and heart rate. Examining cardiovascular reactions to the suppression of painful stimuli might be a fruitful area for future investigation.

Overall, one of the primary effects of suppression on nonverbal behavior was an increase in the duration of several of the most prominent features of the embarrassment display (gaze shifts, looking down, and smile controls). At first blush, this effect of suppression on nonverbal expressions may appear paradoxical. One might have predicted a simple dampening of emotional display across nonverbal behaviors. However, unlike other emotions such as joy or anger, the display of embarrassment, even under conditions in which people are not instructed to suppress, naturally includes several components of suppression and avoidance (e.g., smile controls and gaze shifts). Thus, it is perhaps not really so odd that people engage in these behaviors for longer durations when they are specifically instructed to suppress their embarrassment. Such instructions may simply be enhancing what people naturally do when they find themselves in embarrassing circumstances. It is worth noting that embarrassment itself is paradoxical: The function of the nonverbal displays has been argued to be appeasement, yet people actively try to avoid displaying embarrassment (Castelfranchi & Poggi, 1990; Keltner, 1995; Keltner et al., 1997). Indeed, people can even be embarrassed by being told that they are blushing.

Conclusions

This article is one of the first to examine emotional suppression in a live interpersonal situation. The results, together with those of Gross and colleagues (Gross & Levenson, 1993, 1997; Richards & Gross, 1999), suggest that the primary cost of suppression is in enhanced cardiovascular responding, particularly blood pressure increases. However, some inconsistencies in the literature still remain (e.g., Zuckerman et al., 1981). Some of the differences across studies may reflect differences in the intensity and type of emotion that participants experience. For example, some of the films used in early studies may have elicited less intense emotional responding than the present method, in which a live audience viewed the participant in an embarrassing predicament. It is possible that suppression under less extreme situations may not have the same physiological effects. It is also possible that the effects of suppression vary depending on the type of emotion experienced. Gross and Levenson (1997) have found some consistencies across emotions but have noted differences as well. To explore these issues further and to increase ecological validity, future work might examine other emotional states, particularly as they unfold in interpersonal situations.

References

Alquist, R. P. (1976). Present state of alpha- and beta-adrenergic drugs: I. The adrenergic receptor. *American Heart Journal, 92*, 661–664.

Apsler, R. (1975). Effects of embarrassment on behavior toward others. *Journal of Personality and Social Psychology, 32*, 145–153.

Asendorpf, J. (1990). The expression of shyness and embarrassment. In W. R. Crozier (Ed.), *Shyness and embarrassment: Perspectives from social psychology* (pp. 87–118). New York: Cambridge University Press.

Buck, R. W., Parke, R. D., & Buck, M. (1970). Skin conductance, heart rate, and attention to the environment in two stressful situations. *Psychonomic Science, 18*, 95–96.

Bush, L. K., Barr, C. L., McHugo, G. J., & Lanzetta, J. T. (1989). The effects of facial control and facial mimicry on subjective reactions to comedy routines. *Motivation and Emotion, 13*, 31–52.

Buss, A. H. (1980). *Self-consciousness and social anxiety*. San Francisco: Freeman.

Buss, A. H., Iscoe, I., & Buss, E. H. (1979). The development of embarrassment. *Journal of Psychology, 103*, 227–230.

Castelfranchi, C., & Poggi, I. (1990) Blushing as a discourse: Was Darwin wrong? In W. R. Crozier (Ed.), *Shyness and embarrassment: Perspectives from social psychology* (pp. 230–251). New York: Cambridge University Press.

Colby, C. Z., Lanzetta, J. T., & Kleck, R. E. (1977). Effects of the expression of pain on autonomic and pain tolerance responses to subject-controlled pain. *Psychophysiology, 14*, 537–540.

Cupach, W. R., & Imahori, T. T. (1993). Managing social predicaments created by others: A comparison of Japanese and American facework. *Western Journal of Communication, 57*, 431–444.

Drummond, P. D. (1997). The effect of adrenergic blockade on blushing and facial flushing. *Psychophysiology, 34*, 163–168.

Drummond, P. D. (1999). Facial flushing during provocation in women. *Psychophysiology, 36*, 325–332.

Drummond, P. D., & Lance, J. W. (1987). Facial flushing and sweating mediated by the sympathetic nervous system. *Brain, 110*, 793–803.

Eibl-Eibesfeldt, I. (1972). Similarities and differences between cultures in expressive movements. In R. A. Hinde (Ed.), *Nonverbal communication* (pp. 297–315). Cambridge, England: Cambridge University Press.

Edelmann, R. J. (1987). *The psychology of embarrassment*. Chichester, England: Wiley.

Edelmann, R. J., Asendorpf, J., Contarello, A., Georgas, J., Zammuner, V., & Villanueva, C. (1989). Self-reported expression of embarrassment in five European cultures. *Journal of Cross-Cultural Psychology, 20*, 357–371.

Edelmann, R. J., & Hampson, S. E. (1979). Changes in nonverbal behavior during embarrassment. *British Journal of Social and Clinical Psychology, 18*, 385–390.

Edelmann, R. J., & Hampson, S. E. (1981). Embarrassment in dyadic interaction. *Social Behavior and Personality, 9*, 171–177.

Edelmann, R. J., & Iwawaki, S. (1987). Self-reported expression and consequences of embarrassment in the United Kingdom and Japan. *Psychologia: An International Journal of Psychology in the Orient, 30*, 205–216.

Ekman, P., & Friesen, W. (1978). *Facial action coding system: A technique for the measurement of facial movement*. Palo Alto, CA: Consulting Psychologists Press.

Fonagy, P., & Calloway, S. P. (1986). The effect of emotional arousal on spontaneous swallowing rates. *Journal of Psychosomatic Research, 30*, 183–188.

Goffman, E. (1959). *The presentation of self in everyday life*. Garden City, NY: Doubleday.

Gross, J. J. (1998). Antecedent and response-focused emotion regulation: Divergent consequences for experience, expression, and physiology. *Journal of Personality and Social Psychology, 74*, 224–237.

Gross, J. J., & Levenson, R. W. (1993). Emotional suppression: Physiology, self-report, and expressive behavior. *Journal of Personality and Social Psychology, 64*, 970–986.

Gross, J. J., & Levenson, R. W. (1997). Hiding feelings: The acute effects of inhibiting negative and positive emotion. *Journal of Abnormal Psychology, 106*, 95–103.

Hare, R. D. (1973). Orienting and defensive responses to visual stimuli. *Psychophysiology, 10*, 453–463.

Hartley, T. R., Ginsburg, G. P., & Heffner, K. (1999). Self presentation and cardiovascular reactivity. *International Journal of Psychophysiology, 32*, 75–88.

Huberty, C. J., & Morris, J. D. (1989). Multivariate analysis versus multiple univariate analyses. *Psychological Bulletin, 105*, 302–308.

Jennings, J. R., Kamarck, T. W., Stewart, C. E., Eddy, M., & Johnson, P. (1992). Alternate cardiovascular baseline assessment techniques: Vanilla or resting baseline. *Psychophysiology, 29*, 742–750.

Keltner, D. (1995). Signs of appeasement: Evidence for the distinct displays of embarrassment, amusement, and shame. *Journal of Personality and Social Psychology, 68*, 441–454.

Keltner, D., & Buswell, B. N. (1996). Evidence for the distinctness of embarrassment, shame, and guilt: A study of recalled antecedents and facial expressions of emotion. *Cognition & Emotion, 10*, 155–171.

Keltner, D., & Buswell, B. N. (1997). Embarrassment: Its distinct form and appeasement functions. *Psychological Bulletin, 122*, 250–270.

Keltner, D., Young, R. C., & Buswell, B. N. (1997). Appeasement in human emotion, social practice, and personality. *Aggressive Behavior, 23*, 359–374.

Krantz, D. S., & Manuck, S. B. (1984). Acute psychophysiological reactivity and risk of cardiovascular disease: A review and methodologic critique. *Psychological Bulletin, 96*, 435–464.

Lanzetta, J. T., Cartwright-Smith, J., & Kleck, R. E. (1976). Effects of nonverbal dissimulation on emotional experience and autonomic arousal. *Journal of Personality and Social Psychology, 33*, 354–370.

Lassner, J., Matthews, K., & Stoney, C. (1994). Are cardiovascular reactors to asocial stress also reactors to social stress? *Journal of Personality and Social Psychology, 66*, 69–77.

Latane, B., & Darley, J. (1970). *The unresponsive bystander: Why doesn't he help?* New York: Appelton-Century-Crofts.

Leary, M. R., Britt, T. W., Cutlip, W. D., & Templeton, J. L. (1992). Social blushing. *Psychological Bulletin, 112*, 446–460.

Leary, M. R., & Dobbins, S. E. (1983). Social anxiety, sexual behavior, and contraceptive use. *Journal of Personality and Social Psychology, 45*, 1347–1354.

Leary, M. R., Landel, J. L., & Patton, K. M. (1996). The motivated expression of embarrassment following a self-presentational predicament. *Journal of Personality, 64*, 619–636.

Levenson, R. W. (1992). Autonomic nervous system differences among the emotions. *Psychological Science, 3*, 23–27.

Levenson, R. W., Carstensen, L. L., Friesen, W. V., & Ekman, P. (1991).

Emotion, physiology, and expression in old age. *Psychology and Aging, 6,* 28–35.

Levenson, R. W., Ekman, P., & Friesen, W. V. (1990). Voluntary facial action generates emotion-specific autonomic nervous system activity. *Psychophysiology, 27,* 363–384.

Levenson, R. W., Ekman, P., Heider, K., & Friesen, W. V. (1992). Emotion and autonomic nervous system activity in the Minangkabau of West Sumatra. *Journal of Personality and Social Psychology, 62,* 972–988.

Lewis, M., Stanger, C., Sullivan, M. W., & Barone, P. (1991). Changes in embarrassment as a function of age, sex and situation. *British Journal of Developmental Psychology, 9,* 485–492.

Marcus, D. K., & Miller, R. S. (1999). The perception of "live" embarrassment: A social relations analysis of class presentations. *Cognition & Emotion, 13,* 105–117.

Miller, R. S. (1987). Empathic embarrassment: Situational and personal determinants of reactions to the embarrassment of another. *Journal of Personality and Social Psychology, 53,* 1061–1069.

Miller, R. S. (1996). *Embarrassment: Poise and peril in everyday life.* New York: Guilford Press.

Miller, R. S., & Tangney, J. P. (1994). Differentiating embarrassment and shame. *Journal of Social and Clinical Psychology, 13,* 273–287.

Modigliani, A. (1968). Embarrassment and embarrassability. *Sociometry, 31,* 313–326.

Modigliani, A. (1971). Embarrassment, facework, and eye contact: Testing a theory of embarrassment. *Journal of Personality and Social Psychology, 17,* 15–24.

Obrist, P. A. (1981). *Cardiovascular psychophysiology: A perspective.* New York: Plenum.

Obrist, P. A., Gaebelein, C. J., Teller, S. E., Langer, A. W., Grignolo, A., Light, K. C., & McCubbin, J. A. (1978). The relationship among heart rate, carotid dP/dt, and blood pressure in humans as a function of the type of stress. *Psychophysiology, 15,* 102–115.

Parati, G., Casadei, R., Groppelli, A., DiRienzo, M., & Mancia, G. (1989). Comparison of finger and intra-arterial blood pressure monitoring at rest and during laboratory testing. *Hypertension, 13,* 647–655.

Parrott, W. G., Sabini, J., & Silver, M. (1988). The roles of self-esteem and social interaction in embarrassment. *Personality and Social Psychology Bulletin, 14,* 191–202.

Parrott, W. G., & Smith, S F. (1991). Embarrassment: Actual vs. typical cases, classical vs. prototypical representations. *Cognition & Emotion, 5,* 467–488.

Richards, J. M., & Gross, J. J. (1999). Composure at any cost? The cognitive consequences of emotion suppression. *Personality and Social Psychology Bulletin, 25,* 1033–1044.

Roberts, R. J., & Weerts, T. C. (1982). Cardiovascular responding during anger and fear imagery. *Psychological Reports, 50,* 219–230.

Sabini, J., Siepmann, M., Stein, J., & Meyerowitz, M. (2000). Who is embarrassed by what? *Cognition & Emotion, 14,* 213–240.

Schwartz, G. E., Weinberger, D. A., & Singer, J. A. (1981). Cardiovascular differentiation of happiness, sadness, anger, and fear following imagery and exercise. *Psychosomatic Medicine, 43,* 343–364.

Shearn, D., Bergman, E., Hill, K., Abel, A., & Hinds, L. (1990). Facial coloration and temperature responses in blushing. *Psychophysiology, 27,* 687–693.

Shearn, D., Bergman, E., Hill, K., Abel, A., & Hinds, L. (1992). Blushing as a function of audience size. *Psychophysiology, 29,* 431–436.

Sherwood, A., Dolan, C. A., & Light, K. C. (1990). Hemodynamics of blood pressure responses during active and passive coping. *Psychophysiology, 27,* 656–668.

Sherwood, A., & Turner, J. R. (1992). A conceptual and methodological overview of cardiovascular reactivity research. In J. R. Turner, A. Sherwood, & K. C. Light (Eds.), *Individual differences in cardiovascular response to stress* (pp. 3–32). New York: Plenum Press.

Suarez, E. C., & Williams, R. B. (1989). Situational determinants of cardiovascular and emotional reactivity in high and low hostile men. *Psychosomatic Medicine, 51,* 404–448.

Tangney, J. P., Miller, R. S., Flicker, L., & Barlow, D. H. (1996). Are shame, guilt, and embarrassment distinct emotions? *Journal of Personality and Social Psychology, 70,* 1256–1269.

Turner, J. R. (1994). *Cardiovascular reactivity and stress.* New York: Plenum Press.

Zuckerman, M., Klorman, R., Larrance, D. T., & Spiegel, N. H. (1981). Facial, autonomic, and subjective components of emotion: The facial feedback hypothesis versus the externalizer–internalizer distinction. *Journal of Personality and Social Psychology, 41,* 929–944.

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