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Guilt and pride are heartfelt, but not equally so

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Abstract

We examined the cardiovascular physiology of guilt and pride to elucidate physiological substrates underpinning the behavioral motivations of these moral emotions. Although both emotions motivate prosocial behavior, guilt typically inhibits ongoing behavior, whereas pride reinforces current behavior. To succeed in eliciting real emotions, we used a novel social interaction task. We found dissociable sympathetic activation during guilt and pride; specifically, Guilt participants experienced prolonged cardiac sympathetic arousal as measured by preejection period (PEP), whereas Pride participants experienced transient non-cardiac somatic arousal and a shift to low frequency (LF) power in the cardiac spectrogram. This dissociation supports their distinctive motivational functions. Higher self-reported Behavioral Inhibition System (BIS) sensitivity was furthermore uniquely associated with guilt, supporting its function as a punishment cue.

Descriptors: Moral emotions, Motivation, Sympathetic arousal, Heart rate variability, Behavioral inhibition

Investigating the physiology of discrete emotions serves several important functions, including uncovering emotion-specific physiological activity (Levenson, 2003), and investigating the relation between affect and specific health outcomes (e.g., Lerner, Dahl, Hariri, & Taylor, 2007; Steptoe & Brydon, 2009). Notably, such investigations also help inform psychological theories of emotion with regard to their motivational and behavioral functions (Amodio, Devine, & Harmon-Jones, 2007; Cacioppo & Gardner, 1999; Izard & Ackerman, 2000). Compared to investigations into the basic emotions (e.g., Rainville, Bechara, Naqvi, & Damasio, 2006), however, the psychophysiological exploration of moral emotions has received little attention to date. The dearth of such literature may be attributed largely to inherent methodological challenges associated with the successful elicitation, as well as the measurement, of moral emotions (Lewis, 2000; Tangney, 1996).

Moral emotions are internal affective states that are linked to the wellbeing of other individuals or society as a whole (Tangney, Struewig, & Mashek, 2007). As early as 1884, William James argued that not only basic emotions, but also the moral emotions, are associated with physiological arousal. He maintained that we experience "bodily modifications" unlocking "shames and indignations and fears" that are brought about by our sensitivities to another's perception of the self (James, 1884, p. 195). As ultra-social organisms who stand or fall by our social reputation, moral emotions motivate us to perform socially valued acts while affectively prohibiting socially disruptive ones (Keltner & Buswell, 1997; Tangney et al., 2007). We therefore expect them to wield large physiological responses, corresponding with their strong motivational roles (Williams & DeSteno, 2008).

Guilt and pride are moral self-conscious emotions integral to preserving social bonds. Guilt is an intense, gnawing feeling of moral discomfort experienced when one's behavior violates a personal or societal standard (Baumeister, Stillwell, & Heatherton, 1994). Because guilt is also associated with empathy toward the victim, it can motivate reparative actions (Hoffman, 1998). Conversely, pride is a positive emotion that accompanies both our trivial and life-changing accomplishments (Tracy & Robins, 2004). It therefore provides the psychological motivation or reinforcement for future pride-eliciting behaviors (Williams & DeSteno, 2008). The authentic rather than hubristic form of pride is considered adaptive in that it promotes continued achievement-oriented as well as prosocial behaviors (Tracy & Robins, 2007). Both guilt and pride therefore motivate prosocial or socially adaptive behavior, despite being associated with quite different phenomenological experiences.

Emotions initiate both motor responses and complex goal-directed behavior in order to confer an adaptive advantage upon

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the individual (Cosmides & Tooby, 2000; Frijda, 1986). By this view, the primary function of physiological arousal may not be to determine the emotional response *per se*, but rather to prepare the body for different action programs recruited by the relevant emotion (Davidson, 1994). We therefore hypothesized that the physiology of guilt and pride should reflect their distinctive activation functions: Guilt should disrupt ongoing behavior and operate as a punishment cue (Monteith, Ashburn-Nardo, Voils, & Czopp, 2002), i.e., function as a source of negative arousal; pride, in contrast, should reinforce current behavior and encourage one to perform well again (Tracy & Robins, 2007), i.e., function as a source of positive arousal.

To understand physiological substrates underpinning behavioral motivations associated with guilt and pride more fully, we developed an emotion elicitation paradigm designed to be ecologically valid and intense enough to arouse the autonomic nervous system (ANS). We utilized measures of both sympathetic (SNS) and parasympathetic (PNS) nervous system activity to be able to discriminate between these modes of autonomic control during visceral arousal (Cacioppo, Berntson, Larson, Poehlmann, & Ito, 2000). Porges' (2001, 2007) polyvagal theory emphasizes how different physiological states support distinct forms of behavior: Whereas cardiac SNS activation serves to mobilize bodily resources to cope with threats (i.e., fight or flight), cardiac PNS activation, via the vagus nerve, provides inhibitory input to the heart and facilitates social interaction (see also Porges, 1995). To index vagal activity, we analyzed the high frequency (HF; $>.15$ Hz) and low frequency (LF; .04–.15 Hz) components of heart rate variability (HRV) by way of spectral analysis. The HF variability in the heart rate associated with spontaneous breathing, i.e., respiratory sinus arrhythmia (RSA), is broadly accepted as a relatively pure estimate of vagal control over the heart (Berntson et al., 1997; Hayano et al., 1991). The physiological underpinnings of the LF component are more controversial (Goedhart, Willemsen, Houtveen, Boomsma, & de Geus, 2008). Conceptualizations of LF include it reflecting either a combination of vagal and sympathetic activity (Malliani, Pagani, Lombardi, & Cerutti, 1991; Martinmäki, Rusko, Kooistra, Kettunen, & Saalasti, 2006; Pagani et al., 1991), or baroreflex-mediated vagal activity (Brychta, Shiavi, Robertson, Biaggioni, & Diedrich, 2007; Moak et al., 2009). Despite the uncertainty regarding the source of LF variability in the heart rate, most researchers agree that reduced total HRV (both tonic and excessive reactivity) is nonadaptive and related to increased cardiovascular risk (Thayer & Lane, 2007).

Our measures furthermore allowed us to distinguish between different modes of SNS arousal, given that distinctive regulatory mechanisms are thought to be involved in cardiac and skin sympathetic activity (Rainville et al., 2006): Whereas electrodermal activity is indicative of *somatic* arousal mediated predominantly by sympathetic cholinergic activity (Dawson, Schell, & Filion, 2000), preejection period (PEP) is indicative of *cardiac* SNS arousal mediated by β-adrenergic inotropic drive (Cacioppo, Uchino, & Berntson, 1994).

These SNS indices have been linked to the two primary motivational systems proposed by Gray, viz., the behavior activation system (BAS) and the behavior inhibition system (BIS) (Gray, 1982, 1987; Gray & McNaughton, 2000). Beauchaine (2001) has suggested that both motivational systems are mediated peripherally by the sympathetic nervous system. Specifically, electrodermal activity has been associated with both trait and state anxiety (Katkin, 1965), which are mediated by the BIS (Fowles, 1980; Gray & McNaughton, 2000). In contrast, PEP has been linked to BAS activation because of the functional role of the SNS in mobilizing energy resources for behavioral activation (Beauchaine, 2001; Beauchaine, Gatzke-Kopp, & Mead, 2007; Brenner, Beauchaine, & Sylvers, 2005).

In our experimental paradigm, we relied on interpersonal induction through staged interactions to elicit real emotions of guilt and pride. Contemporary emotion research relies increasingly heavily on such methodology, which is believed to hold more merit and internal validity than hypothetical or remembered scenarios (Harmon-Jones, Amodio, & Zinner, 2007; Herrald & Tomaka, 2002; Williams & DeSteno, 2008). In our Guilt condition, we led participants to believe they were partly responsible for the dismissal of a research assistant. The manipulation was designed to elicit guilt resulting from empathy for a victim, combined with the awareness that one has had an active part to play in another's distress (Hoffman, 1998). For our Pride condition, we employed preprogrammed positive feedback as well as staged interactions with confederates (Herrald & Tomaka, 2002; Williams & DeSteno, 2008), given that pride is most strongly evoked in situations of publicly praised accomplishment (Webster, Duvall, Gaines, & Smith, 2003). We also included a neutral control condition to distinguish physiological responses specific to emotion induction from those due to the experimental context (Stemmler, Heldman, Pauls, & Scherer, 2001). Finally, all participants completed the self-report BIS/BAS scales, in order to determine the relation between BIS and BAS sensitivity and experimentally induced affect (Carver & White, 1994).

Based on previous research suggesting greater autonomic activation in negative than in positive emotions (the so-called "negativity bias"; Cacioppo et al., 2000; Cacioppo & Gardner, 1999), we predicted that guilt would be characterized by greater cardiac reactivity than pride. However, because no study to date has investigated, in a direct manner, the cardiovascular physiology of a current guilt experience, we had no specific hypothesis regarding ANS contributions in this condition. Because of the internal apprehension and anxiety caused by feelings of guilt, we predicted significant sympathetic arousal. For pride we anticipated, based on previous findings (Herrald & Tomaka, 2002), low cardiovascular arousal. Finally, we argued that, because of guilt's function as a punishment cue, a high BIS score would be associated with greater experimentally induced guilt, whereas higher sensitivity for personal reward (i.e., a high BAS score), would be associated with greater experimentally induced pride.

Method

Participants

Fifty-six female participants between the ages of 18 and 25 were recruited from a university population. We recruited only females to avoid confounds due to sex differences in emotional experience, expression of negative emotions, and physiological responses (Manstead, 1992; Shields, 1991; Tangney & Dearing, 2002). In addition, because both confederates were White, an all-White participant sample was recruited to avoid the potential confound of differing cross- and inter-racial attitudes from interfering with the desired emotional response in our social interaction task (Dovidio, Kawakami, & Gaertner, 2002).

Health status of participants was determined by self-report questionnaire. Those with previously diagnosed neurological, psychiatric, cardiovascular, or substance use disorders were excluded. Other exclusion criteria included undergoing medical treatment affecting the circulation, taking any medication for depression or anxiety in the previous 6 months, and being left-handed (Oldfield, 1971). Contraceptive medication was allowed. Participants were informed that they would receive ZAR30 (≈ $US5) as compensation for participating in the 90-min study. The study protocol was approved by the Research Ethics Committee of the University of Cape Town's Department of Psychology.

All participants completed the procedures described below. Seven were excluded before data analysis, however, because of equipment failure ($n = 2$), high scores (>26) on the Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996) ($n = 2$), and post-experimental interviews suggesting they suspected deception ($n = 3$). The final sample thus consisted of 49 healthy females (age: $M = 19.92$ years, $SD = 1.58$).

Self-Report Measures

State affect. Measures of state affect were obtained at baseline (Emotion Time 1) and directly after emotion manipulation (Emotion Time 2). The second affect measure included the same items as the first; however, the order and visual presentation of items differed to disguise the fact that it was a repeated measure. Words describing different affective states were presented individually on the computer interface so that participants could rate their current emotional state on a 9-point Likert-type scale, ranging from 1 (*not at all*) to 9 (*very much*). Single-item measures included guilt, shame, pride, satisfaction, anger, and anxiety. In addition, we created an index for general negative affect (averaged ratings for *sadness, fear*, and *disgust*) as well as an index for general positive affect (averaged ratings for *happiness, hope*, and *relief*). Our primary interest was in single-item ratings of guilt and pride.

BIS/BAS questionnaire. Tendencies toward behavioral inhibition and behavioral activation sensitivity were assessed through the 20-item BIS/BAS scales (Carver & White, 1994). High scores on the BIS scale (7 items) are associated with increased sensitivity to cues of punishment or nonreward, whereas high scores on the BAS scale (13 items) are associated with increased sensitivity to cues of reward. In line with previous findings, BIS and BAS were uncorrelated in our sample ($r = -.01$, $p = .96$).

Physiological Measures

Ambulatory recording. The Vrije Universiteit Ambulatory Monitoring System (VU-AMS, Version 5fs; de Geus & van Doornen, 1996) recorded the electrocardiogram (ECG), impedance cardiogram (ICG), and skin conductance level (SCL) continuously during the experiment. Participants remained seated throughout the procedure and were instructed to refrain from talking and making exaggerated body movements. These precautions were taken to ensure that varying respiratory behavior did not affect physiological recordings (Grossman, Wilhelm, & Spoerle, 2004).

During the experiment, event markers were inserted at predetermined time-points in the manipulation to designate: (i) a neutral period of 90 s that coincided with a button-press task of low attentional load; (ii) the emotion manipulation period of 90 ± 5 s, starting with the entrance of the supervisor and experimenter halfway through the experiment and ending with the supervisor's exit; and (iii) the post-emotion manipulation period that consisted of the 90 s directly after the emotion manipulation and also coincided with the low-load attentional task. A baseline period of 5 min was also recorded. All periods were kept of identical length across different experimental conditions. Because of the nature of the emotion manipulation (i.e., because it depended on the delivery of scripted sentences), the duration of this period varied slightly across participants. Event markers were used as guides to extract physiological data from fixed periods of interest, i.e., from the neutral, emotion manipulation, and post-emotion manipulation periods.

Ambulatory signal scoring. The ambulatory monitoring procedure has been described in detail elsewhere (Goedhart, Kupper, Willemsen, Boomsma, & de Geus, 2006; Goedhart, van der Sluis, Houtveen, Willemsen, & de Geus, 2007; Riese et al., 2003). Briefly, the ECG was recorded from three disposable, pregelled Ag-AgCl electrodes attached in a triangular, equidistant configuration on the precardium, with signals sampled at 500 Hz. The recorded interbeat interval (IBI) time series was visually inspected for physiologically implausible readings. Artifacts were corrected by summing spuriously short IBIs, while missing beats were 'created' by splitting spuriously long IBIs ($>99\%$ of data were free of artifacts). From the ECG tachograms we calculated HR as well as power spectral densities via autoregressive (AR) analysis. The AR analyses were done via a software package from the Biomedical Signal Analysis Group (Department of Applied Physics, University of Kuopio, Kuopio, Finland), using a model order of 15 and an interpolation rate of 5 Hz. To obtain valid HRV estimates, we extended our neutral and emotion manipulation periods for these analyses from 90 s to 120 s (Task Force, 1996). Frequency bands assessed included respiratory or high frequency (HF; .15–.40 Hz), low frequency (LF; 0.04–.15 Hz), and the sum of HF and LF, total frequency (TF; .04–.4 Hz). All calculated msec^2 power values were transformed via natural logarithm to normalize the distributions.

The ICG was monitored using a four spot-electrode configuration consisting of two electrodes at the back, which supplied high-frequency current, and two measuring electrodes on the chest, to detect the voltage drop over the thorax. The electrical resistance through the chest was thus measured as a function of blood volume variation while passing a constant current of 350 μA, 50 kHz through the chest cavity. Resulting measures included basal thoracic impedance (Z_0) and the first derivative of basal impedance (dZ/dt, sampled at 500 Hz), from which several systolic time interval indices of cardiac contractility (e.g., PEP) could be calculated. The impedance data were ensemble-averaged over 30-s intervals, and a manual scoring procedure detailed by Sherwood et al. (1990) was used to identify certain waveform components necessary to calculate PEP. PEP scoring was quantified as the time interval in milliseconds between the ECG Q-wave and the B-point in the ICG, which is the start of the rapid upslope of the dZ/dt waveform to its maximum. PEP was calculated as the mean value of all 30-s ensemble averages within fixed periods of interest (Riese et al., 2003).

SCL was recorded as an index of emotional arousal independent of valence (Lang, Greenwald, Bradley, & Hamm, 1993). We used the constant voltage method (0.5 V), sampled at 10 Hz, to measure electrodermal activity in standard microSiemens (μS) conductance units. Ag-AgCl, non-polarizable finger electrodes (6 mm diameter contact area; BiopacSystems, Inc.) filled with isotonic, 0.5% saline gel (GEL101, BiopacSystems, Inc.) were attached to the distal phalanx surfaces of participants' middle and index fingers of the nondominant left hand. Participants were requested to rest their left hands on the table during the experimental procedure.

Setting and Procedure

Each participant was randomly assigned to either a Guilt ($n = 16$), Pride ($n = 16$), or Neutral ($n = 17$) condition. After signing consent documents and completing sociodemographic, mood, and personality measures (i.e., BDI-II, BIS/BAS), each participant was guided to a curtained-off section of the laboratory. This area housed two computers (one for data acquisition and one dummy), as well as the VU-AMS5fs and electrodes used for physiological recordings. The experiment's cover story was that participants would practice some computerized working memory tasks to assess associated physiological change. Two female actors performed as confederates to heighten the realism of the setup. The dialogue between the experimenter and her confederates was carefully scripted, as were the lines the experimenter and confederates delivered to the participants.

Pre-manipulation procedures. The experimenter explained to participants that a research assistant (Confederate #1) would assist in task administration because she (the experimenter) was needed elsewhere and could not stay for the full testing period. While the experimenter introduced the experimental procedures, the supervisor (Confederate #2) entered the laboratory and requested that the experimenter meet with her as soon as possible. The experimenter therefore left the laboratory while the assistant remained with the participant. She attached all electrodes necessary for physiological measurements and once signal integrity was established, recorded a baseline rest period (5 min). The research assistant also explained that no verbal communication was allowed during the experiment to ensure signal integrity.[1]

Experimental manipulation: Guilt condition. In this condition, the research assistant gave participants more money than the normal compensation amount (ZAR60 instead of ZAR30), indicating that this offer was not standard procedure and should be kept secret. As justification for the extra compensation, the assistant mentioned that some participants did not show up for testing and that the supervisor would not miss the money. The assistant left as participants began performing the computerized tasks. Later, the supervisor and experimenter unexpectedly returned. This entrance was timed to take place as participants finished a block of tasks. Upon discovering money missing, the supervisor interrogated the participant, asking her directly whether she had been given more than ZAR30 by the research assistant. When participants confirmed this through a nod of the head (they were still under instructions not to speak), the supervisor communicated her feelings that the assistant was untrustworthy and slack and needed to be fired. The supervisor furthermore instructed the experimenter to hire a new assistant as soon as possible, and to finish off the experiment while she dealt with the assistant. Participants were therefore left to understand they had some agency in the misfortune of the kind assistant.

[1]This control measure was enforced in all three conditions to minimize physiological confounds due to respiratory changes.

Experimental manipulation: Pride condition. Pride condition participants underwent a similar procedure as those in the Guilt condition, but with these exceptions: (i) they were not offered extra money, and (ii) they received bogus visual and verbal performance feedback aimed at eliciting achievement-oriented pride (e.g., Williams & DeSteno, 2008). During the instruction phase, the experimenter informed the participant that her test scores would be transferred to a 'host computer' (i.e., the dummy computer). When the supervisor and experimenter unexpectedly returned midway through the tasks, the supervisor ostensibly noticed the exceptional scores on the 'host computer' and warmly congratulated the participant, telling her that she was "outperforming most other candidates" and that she should "keep it up." Participants also received predetermined normative information suggesting superior performance (e.g., a high percentile score and congratulatory sentence) after each computerized task block (Webster et al., 2003).

Experimental manipulation: Neutral condition. Neutral condition participants experienced a similar context to those in the emotion elicitation conditions, but did so without any emotional overlay. They thus did not receive extra money or performance feedback, and all dialogue between confederates, as well as questions posed to the participant, featured neutral content. This condition served to determine the magnitude and direction of physiological changes specific to emotion elicitation and distinct from the experimental context (Stemmler, 1989).

Post-experimental procedures: Debriefing interview. The debriefing session took the form of a funneled approach, where the experimenter first carefully probed participants for suspicion while maintaining the cover story, followed by more specific questions relating to their experiences during the experiment (Harmon-Jones et al., 2007). The debriefing session thus served an important purpose in verifying that target emotions were actually experienced (Levenson, 2003). Participants were then debriefed in full about the true nature of the investigation and were asked not to discuss the experiment with fellow students.

Results

Manipulation Check: Self-Report

There were no between-group differences with regard to baseline state affect ($ps > .10$, $rs < .30$). Analyses of state affect changes from pre-manipulation (Emotion Time 1) to post-manipulation (Emotion Time 2) showed that Guilt condition participants significantly increased their ratings of guilt, as well as those of anxiety, anger, general negative affect, and shame, $ts(15) > 3.50$, $ps < .01$, $rs > .60$. Their ratings of pride decreased slightly, $t(15) = 1.78$, $p = .09$, $r = .42$. Although ratings of guilt increased the most ($M = 3.31$, $SD = 2.33$ to $M = 6.81$, $SD = 1.81$; $t(15) = 4.09$, $p = .001$, $r = .73$), this change was not statistically significant compared to increases in other negative emotions ($ps > .10$, $rs < .40$).

Pride condition participants significantly increased their ratings of pride ($M = 4.75$, $SD = 2.08$ to $M = 6.38$, $SD = 1.93$; $t(15) = 3.26$, $p = .005$, $r = .64$), as well as those of general positive affect ($p = .04$, $r = .50$), but not satisfaction ($p = .67$, $r = .11$). Their ratings of guilt showed a significant decrease, $t(15) = 2.28$, $p = .04$, $r = .51$. Neutral condition participants did not change their ratings of either guilt or pride from pre- to post-manipulation ($ps > .15$, $rs < .35$).

To investigate affect differences across experimental groups, a 2-way (group × emotion) linear mixed model was fitted for the eight Emotion Time 2 scores in each experimental condition with a random effect for participant to model the correlated data (Table 1). The type 3 tests for fixed effects were considered for overall significance of the effects. Conditional on the overall test for the interaction being significant, suitable contrasts were set up to test significant affect differences from the Neutral condition.

Results for the linear mixed model indicated that the overall 2-way interaction was significant, $F(14,322) = 11.66$, $p < .001$. Pairwise comparisons indicated that all negative emotions were rated as significantly higher in the Guilt compared to the Neutral condition (ps $< .001$). The group difference for guilt, however, was larger than the average difference of all other negative emotions (Estimate $= -1.81$, Standard Error $= 0.48$, $t = -3.75$, $p < .001$) (Figure 1). Similarly, pairwise comparisons indicated that all positive emotions were significantly higher in the Pride compared to the Neutral condition (ps $< .02$). Group differences indicated that, although the difference for pride was not larger than that for the other positive emotions ($p = .34$), it was larger than the average difference of *all* emotions (Estimate $= -1.52$, Standard Error $= 0.61$, $t = -2.51$, $p < .01$) (Figure 1).

Taken together, the results confirmed that guilt and pride, respectively, were elicited more strongly than any other emotion by the emotion manipulation conditions.

Individual Differences: BIS/BAS

Partial correlations controlling for baseline affect (Emotion Time 1) indicated that BIS, but not BAS, was positively related to experimentally induced guilt (Emotion Time 2), $r = .58$, $p = .02$. Residualized post-manipulation scores for other emotions (i.e., Emotion Time 1 scores covaried) indicated that BIS was not significantly related to any other negative affect: anxiety ($r = .34$, $p = .22$), anger ($r = .07$, $p = .81$), shame ($r = .47$, $p = .08$),[2] or general negative affect ($r = .26$, $p = .34$). We found no significant correlations between experimentally induced pride and the overall BAS scale ($r = -.34$, $p = .22$), or any of its subscales (i.e., Drive, Reward Responsiveness, and Fun Seeking).

Physiological Responses

Baseline and neutral period analyses and analysis strategy. All participants engaged in a 5-min baseline period and a 90-s neutral period that were identical across all three experimental conditions. Because the neutral period corresponded better to the emotion manipulation period in length and attention-demand, this period was used in all analyses as the control period against which to assess physiological change. One-way analyses of variance (ANOVAs) detected no significant between-group differences on any physiological parameter during the neutral period (ps $> .20$, rs $< .25$). To determine emotion-specific physiological changes, one-way analyses of covariance (ANCOVAs) were performed with emotion condition as the between-subjects factor and reactivity during the neutral period as the covariate. Figure 2 displays the average within-subjects additional reactivity or change scores during the emotion manipulation and post-manipulation periods.

Emotion-Manipulation Effects

SCL. The ANCOVA with maximum SCL during emotion manipulation as the dependent variable was significant, $F(2,45) = 6.68$, $p = .003$, $\eta^2 = .23$. *Post-hoc* contrasts indicated significantly higher SCL for Guilt and Pride participants compared to Neutral participants ($p = .001$, $r = .47$ and $p = .03$, $r = .31$). SCL of Guilt and Pride participants did not significantly differ ($p = .20$) (Figure 2A).

HR. This ANCOVA[3] detected significant between-group differences during emotion manipulation, $F(2,44) = 5.11$, $p = .01$, $\eta^2 = .19$. *Post-hoc* contrasts indicated that HR of Guilt participants was significantly higher than that of Neutral, but not Pride, participants ($p = .003$, $r = .42$). HR of Pride participants was not significantly higher than that of Neutral participants ($p = .06$). Group differences became more pronounced during the post-emotion manipulation period, $F(2,44) = 8.92$, $p = .001$, $\eta^2 = .29$, with Guilt participants' HR significantly higher than Neutral ($p < .001$, $r = .50$), as well as Pride ($p = .007$, $r = .38$), participants (Figure 2B).

PEP. This ANCOVA[4] detected significant between-group differences during emotion manipulation, $F(2,45) = 9.53$, $p < .001$, $\eta^2 = .29$, which again became more pronounced during the post-emotion manipulation period, $F(2,45) = 15.26$, $p < .001$, $\eta^2 = .41$. During both periods, significantly shorter preejection periods were observed for Guilt participants compared to both Pride and Neutral participants (ps $< .001$, rs $> .45$) (Figure 2C). Although PEP and SCL both reflect sympathetic arousal, no significant correlations were observed between PEP and SCL reactivity scores, either during or after the emotion manipulation (rs $< .35$, ps $> .18$).

Frequency domain HRV analysis. Because of the necessity of extending our measuring periods for HRV frequency analyses to 120 s (Task Force, 1996), we only examined HRV effects during emotion manipulation, thus starting at the beginning of the emotion manipulation period and extending 30 s into the post-emotion manipulation period. The ANCOVA for HF power data detected significant between-group differences, $F(2,45) = 4.61$, $p = .02$, $\eta^2 = .17$. *Post-hoc* contrasts indicated that HF power of both Guilt and Pride participants were significantly lower than that of Neutral participants, $p = .007$, $r = .38$, and $p = .03$, $r = .32$, respectively (Figure 3A). The ANCOVA for LF power was also significant, $F(2,45) = 8.48$, $p = .001$, $\eta^2 = .27$. *Post-hoc* contrasts indicated that Guilt participants had reduced LF power during the emotion manipulation compared to both Pride and Neutral participants (ps $= .001$, rs $> .47$), while LF power did not differ between Pride and Neutral participants ($p = .75$) (Figure 3B). Analysis of TF power yielded between-group differences similar to LF power, $F(2,45) = 12.44$, $p < .001$, $\eta^2 = .36$, and confirmed that the Guilt group was the only experimental group with significantly reduced total heart rate variability (ps $< .001$, rs $> .49$) (Figure 3C).

To further explore the physiological origin of the LF component, we performed correlations between LF and HF power for the neutral and emotion manipulation periods across experimental conditions. Consistent with previous findings

[2]In the case of shame, the correlation with BIS may have reached significance if the sample size was larger. This is not surprising, however, given the highly correlated nature of guilt and shame in response to self-caused wrongdoing (Schmader & Lickel, 2006).

[3]HR data were reciprocally transformed to minimize large variability across participants.

[4]PEP data were reversed and natural log transformed to correct for negative kurtosis.

Table 1. *Post-Manipulation (Emotion Time 2) Ratings From 1 (Not At All) to 9 (Very Much) for the Three Experimental Conditions*

	Neutral (n = 17)			Pride (n = 16)			Guilt (n = 16)		
	Mean (*SD*)	Min	Max	Mean (*SD*)	Min	Max	Mean (*SD*)	Min	Max
Anger	1.24 (0.44)	1.00	2.00	1.44 (0.96)	1.00	4.00	4.50 (2.16)	2.00	9.00
Guilt	1.53 (1.46)	1.00	7.00	1.63 (0.89)	1.00	3.00	6.81 (1.83)	4.00	9.00
Pride	4.53 (2.27)	1.00	8.00	6.38 (1.93)	3.00	9.00	3.50 (2.03)	1.00	7.00
Satisfaction	4.88 (2.09)	1.00	8.00	6.50 (1.67)	2.00	9.00	3.56 (2.03)	1.00	8.00
Shame	2.00 (1.77)	1.00	7.00	1.38 (0.72)	1.00	3.00	5.38 (2.22)	2.00	9.00
Anxiety	2.88 (2.00)	1.00	8.00	2.88 (1.82)	1.00	6.00	6.81 (1.38)	4.00	9.00
General positive	4.73 (1.57)	1.67	7.33	5.90 (1.34)	2.33	7.67	4.29 (1.72)	1.00	7.33
General negative	1.82 (1.26)	1.00	5.67	1.63 (0.88)	1.00	4.00	5.15 (1.49)	1.67	7.67

Note: General positive = averaged ratings for happiness, hope, and relief. General negative = averaged ratings for sadness, fear, and disgust.

(Martinmäki et al., 2006), LF and HF power were significantly correlated across these periods ($rs > .45$, $ps \leq .001$).

Discussion

Self-conscious moral emotions of guilt and pride motivate adaptive social behaviors (Leary, 2007). We created a social psychology paradigm of high ecological validity to investigate associations between guilt and pride's behavioral responses and their underlying physiological substrates. Our data not only confirmed effective emotion elicitation, but uncovered a *cardiac* SNS arousal pattern for guilt versus a *somatic* SNS arousal pattern for pride. This novel finding provides support for these emotions' distinct motivational functions and may be extrapolated to predict the impact of these emotions on psychophysiological processes outside the laboratory. Additionally, high punishment sensitivity (as measured by Carver and White's BIS scale) was uniquely associated with greater self-reported guilt, while we found no relation between reward sensitivity (as measured by the overall BAS scale or any of its subscales) and self-reported pride.

Subjective Emotional Responses

Both univariate and multivariate analyses of self-report data confirmed that guilt and pride were preferentially elicited in the respective emotion manipulations. No explicit verbal references to these emotions were made during any part of the experiment, suggesting that these emotions were truly felt. In the Guilt condition, participants primarily reported feeling guilty, together with experiencing other negative emotions (i.e., anxiety, anger, shame, and general negative affect), whereas participants in the Pride condition reported mostly pride and satisfaction. Although emotion researchers typically try to elicit pure emotions, it is well established that different emotions often co-occur, and that, together, they may represent the particular emotional profiles that provide an adaptive advantage for the individual (Izard & Ackerman, 2000). Pride, for example, has also previously been conceptualized as the mean response to ratings of pride and satisfaction (Williams & DeSteno, 2008).

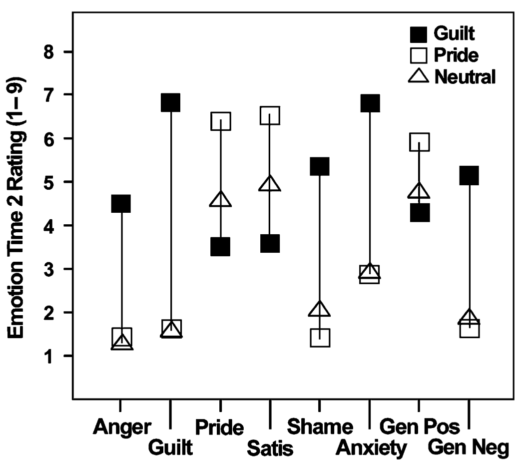

Figure 1. Differences between participants' mean state affect reported after emotion manipulation (i.e., Emotion Time 2 ratings). Satis: satisfaction, Gen Pos: general positive affect, Gen Neg: general negative affect.

For our purposes, however, it was important to distinguish guilt from the similar emotion of shame, even though these emotions have been reported to be much more highly correlated in response to self-caused than other-caused wrongdoing (Schmader & Lickel, 2006). Whereas a particular action is regarded as negative in guilt, the entire self is typically regarded as negative in shame (Lewis, 1971). We therefore probed for guilt-related beliefs (i.e., thoughts that one had played a causal role and should have thought, felt, or acted differently) during the post-experimental interviews. Typical responses included "feeling guilty about getting the lab-assistant into trouble," "wishing I never took the money," and "wanting to write a letter to apologize." In addition, as an indication of prosocial behavior, 9 out of 16 Guilt participants volunteered to give the money back as soon as the experiment concluded. It therefore appeared they were experiencing a deep regret over wrongdoing, accompanied by sincere empathy for the research assistant (who had ostensibly lost her job). Our results are consistent with a multidimensional model of guilt (Kubany & Watson, 2003), because both negative affect and guilt-related cognitions could be identified.

Somatovisceral Responses of Guilt and Pride

The physiological data supported clear between-group ANS differences: Whereas Guilt and Pride participants displayed similar levels of general arousal (i.e., SCL) compared to Neutral participants, only those in the Guilt condition displayed significantly increased HR. The HR changes of Guilt participants were associated with reciprocal modulation of sympathetic (i.e., decreased PEP) and vagal (i.e., decreased HF power) outflows to the heart, with decreased PEP persisting through the post-emotion manipulation period. The modest HR increases of our Pride participants were consistent with previous findings of low cardiac reactivity during pride or other positive emotions like happiness

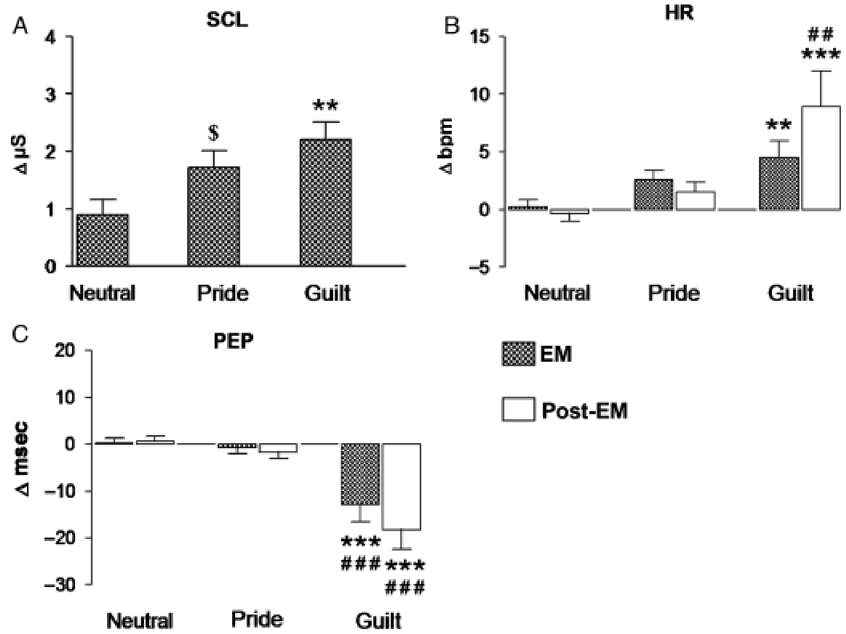

Figure 2. Physiological change scores (from the neutral period) for the Neutral, Pride, and Guilt conditions during EM and Post-EM. (A) SCL, (B) HR, (C) PEP. EM: emotion manipulation period, Post-EM: post-emotion manipulation period, SCL: skin conductance level, HR: heart rate, PEP: preejection period. $^{**}p<.01$ and $^{***}p<.001$ Guilt compared to the Neutral condition. $^{\$}p<.05$ Pride compared to the Neutral condition. $^{\#\#}p<.01$ and $^{\#\#\#}p<.001$ Guilt compared to the Pride condition.

and contentment (Ekman, Levenson, & Friesen, 1983; Fredrickson & Levenson, 1998; Herrald & Tomaka, 2002).

Interestingly, both Guilt and Pride participants displayed attenuated HF power during emotion manipulation. In Pride participants, however, the decrease in HF power was accompanied by a shift to LF power (TF power remained unchanged), in the absence of significant HR increases. In line with literature, our data provided strong support for vagal modulation of LF, in that LF power was strongly correlated with HF power during all experimental conditions (Martinmäki et al., 2006). Increases in

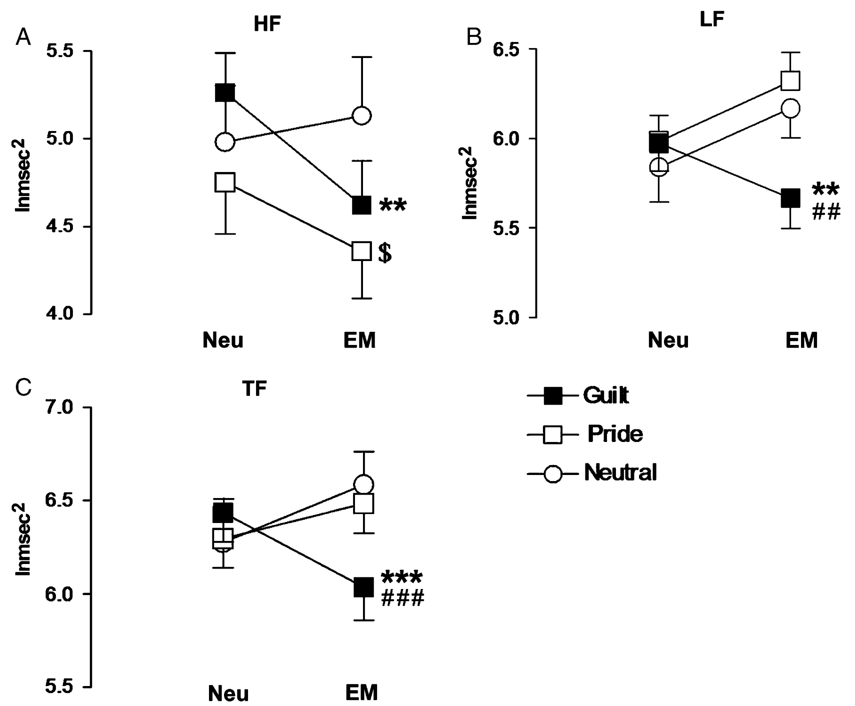

Figure 3. Power spectral densities of the three experimental conditions during the neutral and emotion manipulation periods. (A) HF, (B) LF, (C) TF. Neu: neutral experimental period, EM: emotion manipulation period, HF: high frequency power, LF: low frequency power, TF: total frequency power. $^{**}p<.01$ and $^{***}p<.001$ Guilt compared to the Neutral condition. $^{\$}p<.05$ Pride compared to the Neutral condition. $^{\#\#}p<.01$ and $^{\#\#\#}p<.001$ Guilt compared to the Pride condition.

cardiac LF power are thought to reflect *somatic* SNS activation of vasomotor nerves, with the resultant vasoconstriction then leading to baroreflex-mediated vagal modulation (Brychta et al., 2007; Moak et al., 2009). Because Pride participants displayed no PEP shortening, we interpreted the reciprocal change in cardiac spectral power in these participants as a shift from respiratory-mediated to baroreflex-mediated vagal drive. This is in stark contrast to the pronounced PEP shortening (reflecting *cardiac* SNS activation) experienced by Guilt participants. The fact that PEP and SCL were not correlated in any experimental condition further substantiated our interpretation of these variables as reflecting cardiac and somatic arousal, respectively.

Although previous research has suggested that different, organ-specific SNS activation patterns operate during mental compared to physical stressors (Wallin et al., 1992), our results provide compelling evidence of differential SNS activity during discrete *emotional* reactions. Whereas the experience of guilt appeared to produce both cardiac and somatic SNS arousal, our data suggested that SNS arousal associated with pride was not cardioselective in this way.

Few studies have specifically looked at changes in HRV during discrete emotional states. Our finding of respiratory-mediated vagal unloading during guilt and pride is consistent with previous reports detailing decreased RSA amplitude following exposure to either positive or negative emotional stimuli (Frazier, Strauss, & Steinhauer, 2004; Rainville et al., 2006; Ritz, Alatupa, Thons, & Dahme, 2002). This response purportedly enables an individual to rapidly engage with the environment, whether in approach- or withdrawal-related fashion (Porges, 1995, 2001). The pride response, however, was arguably physiologically less pressing than guilt: Total HRV was not reduced in this condition, indicative of preserved physiological flexibility (Porges & Byrne, 1992). The pronounced shift to LF power in our Pride participants also mimicked a response previously observed during the positive emotion of appreciation (McCraty, Atkinson, Tiller, Rein, & Watkins, 1995). In McCraty et al.'s appreciation condition, participants were required to sincerely feel appreciation or another positive emotion toward someone by focusing on their heart. A strong increase in spectral power was observed around 0.1 Hz (Mayer waves), which is similar to the LF peak of 0.096 ± 0.02 Hz measured in our Pride participants.

By comparison, the reduction in HRV across the TF band coupled with the increased sympathetic activity experienced by our Guilt participants resembles an overall stress response pattern (e.g., Friedman & Thayer, 1998). This response may, however, have been augmented by the experimental context. Stemmler (1989) has argued against absolute emotion specificity, promoting instead the view that the specific context counts. According to the component model of somatovisceral response organization (Stemmler, Aue, & Wacker, 2007; Stemmler et al., 2001), variation in an emotional response may be brought about by both the physical context as well as the contextual demands of the situation. The latter includes any motivational and behavioral demands necessitated by the momentary situation. Taking these considerations into account, it may be possible that participants in our Guilt condition experienced an amplified physiological response because they were unable to speak or rectify the situation immediately. Suppression, or keeping affect (negative or positive) from being expressed, has often been reported to correspond with greater magnitudes of sympathetic arousal (Ochsner & Gross, 2004). This amplified sympathetic arousal or physiological cost, however, was not observed in our Pride participants, despite the fact that they also received the instruction to refrain from talking.

Behavioral Motivation

Guilt has been described as a form of anxiety associated with the threat of social exclusion due to misconduct (Baumeister, Stillwell, & Heatherton, 1995). This anxiety is thought to be adaptive in that it promotes reinforcement learning, while simultaneously inhibiting the transgressive behavior (Monteith, 1993; Monteith et al., 2002). In this way, guilt functions as a punishment cue to help the individual respond more carefully in future (Devine, Monteith, Zuwerink, & Elliot, 1991). Making amends, however, has been suggested as a line of action that may relieve or resolve guilt-associated distress and "give rise to positive-affect-evoking cognitions that counteract the negative affect" (Izard, 1991; Kubany & Watson, 2003, p. 77).

Our finding of a positive correlation between behavioral inhibition sensitivity, as measured by the BIS/BAS scales, and experimentally induced guilt, supports the idea that initial guilt functions as a punishment cue. Gray (1982) proposed that individuals high in BIS sensitivity will be sensitive to punishment cues, and that this sensitivity will result in greater negative affect (in this case, guilt), as well as the interruption of ongoing action, during specific situations of threat. Recent findings on the neurocognitive correlates of the Carver and White scales have confirmed that BIS is associated with conflict monitoring and the interruption of action, rather than behavioral avoidance (Amodio, Master, Yee, & Taylor, 2008). We therefore agree with previous accounts and argue that guilt-related anxiety, together with guilt cognitions, functions as a punishment cue that inhibits ongoing behavior and encourages reparatory behavior in order to alleviate distress (both personal as well as distress caused to another). This view is consistent with the notion that guilt facilitates a multifaceted self-regulatory process, starting with behavior inhibition and transforming into approach-oriented, conciliatory behavior when an opportunity for amendment appears (Amodio et al., 2007).

Several theorists have argued convincingly for physiological markers of BIS and BAS activation during tasks that are designed to activate these motivational tendencies (Beauchaine, 2001; Fowles, 1980). Putative physiological correlates of BIS and BAS, however, do not always replicate well across studies and have been found to be largely uncorrelated with self-reported BIS and BAS (Brenner et al., 2005; Heponiemi, Keltikangas-Järvinen, Kettunen, Puttonen, & Ravaja, 2004; Knyazev, Slobodskaya, & Wilson, 2002; Morgan, 2006). Because of these considerations, we interpret our physiological data in terms of BAS and BIS activation with caution. Before proceeding, we also acknowledge recent changes to the original BIS theory. The revised theory makes strong distinctions between anxiety, which is mediated by BIS, and fear, which is mediated by a separate fight/flight/freeze system (FFFS) (McNaughton & Corr, 2004). According to these current theoretical accounts, BIS is activated when the subject experiences conflict between competing motivational tendencies (e.g., approach-avoidance, approach-approach, or avoidance-avoidance), and is therefore often activated by the simultaneous activation of the FFFS and BAS (when they are of similar intensity). BIS activation has the effect of inhibiting prepotent behavior, but also induces anxiety and increased autonomic arousal, which facilitates behaviors aimed at resolving the conflict, e.g., risk assessment.

In the case of guilt, the acute emotional reaction intuitively activates both the FFFS (i.e., freezing in response to threat detection) and BAS (i.e., behavioral activation or active avoidance); it therefore follows that conflict between these systems would result in increased BIS activation. This description is consistent with our experimental results for guilt, in that guilt was associated with increased punishment sensitivity (i.e., FFFS), increased BAS activity (i.e., PEP; Brenner et al., 2005), increased BIS activity (i.e., SCL; Fowles, 1980), and increased arousal (i.e., RSA; Frazier et al., 2004). In addition, anxiety was the second most highly rated emotion in our Guilt condition. Hypothetically speaking, the competition between BAS-mediated appetitive motivation and the fight/flight/freeze system may eventually be tipped in favor of approach for guilt (i.e., guilt-related amending behavior), whereas it might be tipped in favor of avoidance in the case of shame. This account of guilt's motivational direction is in line with Amodio et al.'s (2007) findings; through use of frontal cortical asymmetry, they showed that guilt is initially associated with reduced approach motivation, followed by increased approach motivation during engagement in prosocial activity.

Pride's physiological response is also consistent with its psychological function, namely, to fuel and reinforce socially valued acts (Tracy & Robins, 2007). Increases in relative LF power at the expense of HF power in the cardiac spectrogram have recently been described as a measure of decreased chaos (i.e., less influence from HF breathing rate changes that are unpredictable or chaotic in nature) in the cardiovascular system (Wu et al., 2009). The lesser contributions of HF, and concomitant greater contributions of LF, to cardiac spectral power during pride should therefore decrease the homeostatic demands on the body and facilitate positive affect. In our manipulation, pride thus served to decrease the inherently chaotic HF power but not the total power in HRV, and furthermore increased somatic SNS arousal. This transient non-cardiac SNS arousal in pride can be viewed as 'being in the zone,' i.e., SNS-aroused but not stressed, relaxed yet focused—a pleasurable feeling that should encourage future pride-eliciting behaviors.

In terms of motivation, pride has recently been described as the "most important human emotion" to motivate social behavior (Tracy & Robins, 2007, p. 147). When we succeed in a task or meet a goal, feelings of pride are associated with increased social interaction (Noftle & Robins, cited in Tracy & Robins, 2007), enhanced performance at subsequent tasks (Herrald & Tomaka, 2002), as well as increased efforts toward future goals despite short-term losses (Williams & DeSteno, 2008). The achievement-oriented form of pride is thus consistent with behavioral approach, or activation of movement toward positive self-rewarding goals, as measured by the BIS/BAS scales (Fowles, 1980; Gray, 1982).

In our Pride condition, however, we found no positive correlation between BAS sensitivity and experimentally induced pride; nor was there a significant increase in HR or PEP reactivity, putative physiological markers of BAS (Arnett & Newman, 2000; Brenner et al., 2005; Fowles, 1980), compared to the Neutral condition. The most feasible explanation may be that our pride manipulation did not include any specific reward incentives and that it therefore may not have produced significant changes in behavioral activation. Our pride manipulation was also less intense than the guilt manipulation, and therefore may have led to only marginal increases in behavioral activation. A third possibility, however, and the explanation we favor, assumes that pride, like guilt, involves different stages. Initially, pride follows a completed success and serves to provide information about an individual's current social status (Tracy & Robins, 2007); it is therefore unlikely to motivate immediate further action (i.e., BAS). After a while, however, a new challenge appears and it is then that 'higher' pride will activate more action than 'low' pride. This view is consistent with the fact that, unlike negative emotions, positive emotions in general are not associated with specific action programs that motivate immediate further actions (Frijda, 1986). We therefore propose that initial pride, as measured in our pride manipulation, does not motivate behavioral activation.

Limitations and Directions for Future Research

The current study's results reinforce the importance of studying emotions *in vivo* and in ecologically valid settings. A number of potential methodological limitations, however, need to be addressed. In our study we did not analyze respiration, we were therefore not able to distinguish between respiration-dependent and respiration-independent PNS activity (Rainville et al., 2006), or to verify that respiration fell within the HF band. Houtveen and colleagues (2002), however, showed that respiratory-corrected RSA did not produce a better estimate of vagal modulation of heart rate in most stress situations. Moreover, our experimental manipulation was not expected to alter respiratory parameters appreciably (participants neither talked nor moved), in which case uncorrected RSA may be permissible for group contrasts (Berntson et al., 1997).

Another limitation is the 500-Hz sampling rate we employed for physiological recording, which is below gold standard for ICG recording. Reliable impedance data, however, have been obtained even at 250 Hz using similar instrumentation. In particular, PEP estimates obtained at these lower sampling rates have been reported to have high short-term and temporal stability (Goedhart et al., 2006; Vrijkotte, van Doornen, & de Geus, 2004), as well as high heritability (Kupper, Willemsen, Boomsma, & de Geus, 2006).

A third limitation is that, in terms of the experimental design, our use of a between-subjects design over multiple experimental conditions may have introduced unwanted sources of physiological variability between participants, despite our efforts to covary out baseline differences. Within-subject designs, however, are not necessarily a good solution to this problem, because their internal validity is easily threatened (Cook & Campbell, 1979). They may, for instance, suffer from adaptation and order effects, or be entirely impractical in designs requiring deception in that the element of surprise is sacrificed (Stemmler et al., 2001).

A fourth limitation involves the fact that we investigated guilt and pride in a female-only sample. As noted earlier, we did so to avoid confounds due to possible sex-by-emotion effects. Although guilt and pride have been shown to function in the same way for men and women (Monteith et al., 2002; Tracy & Robins, 2008), women typically report more intense emotional experiences than men (Gross & John, 1998), and often respond more sensitively to negative emotional stimuli (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Nater, Abbruzzese, Krebs, & Ehlert, 2006). Sex differences in the physiological domain of emotion, however, remain unclear (Brody, 1999), with a possible confounding factor being the emotion manipulation itself. Some evidence suggests that sex differences in physiological arousal disappear when men and women are exposed to situations that they find equally important or arousing (Frodi, 1976). We therefore do not expect men and women to have different physiological responses for guilt and pride per se, but we do expect that there may be some differences in the emotion manipulations required to elicit these emotions to the same extent in both sexes.

In terms of emotion specificity, our data are consistent with the notion of distinct physiological arousal patterns for discrete emotions, yet this study was not designed with an aim of confirming Jamesian emotion theory. To confirm autonomic specificity for the moral emotions, we would also have to demonstrate autonomic differentiation between similarly valenced moral emotions (Levenson, 2003). A fruitful line of future investigation may therefore be to investigate autonomic differences between negative moral emotions (e.g., guilt, shame, and embarrassment) and between positive moral emotions (e.g., elevation, gratitude, and pride). Future studies may also explore the pride response in relation to a moral act of goodwill, instead of the performance-based pride that is usually investigated in laboratory paradigms. Finally, more research is needed to elucidate the long-term health implications of these emotions.

In conclusion, the central finding of this study was the strong but dissociable sympathetic arousal during current experiences of guilt and pride. Whereas guilt was associated with reciprocal vagal withdrawal and cardiac sympathetic arousal, in pride the SNS activity was manifested by transient non-cardiac somatic arousal. Self-reported guilt was furthermore positively correlated with BIS sensitivity, supporting the conceptualization that early guilt functions as a punishment cue. In contrast, bodily arousal in early pride may be associated with a positive feeling that will induce future pride-eliciting behavior.

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