Affective and Physiological Responses to the Suffering of Others: Compassion and Vagal Activity

Jennifer E. Stellar
University of Toronto

Adam Cohen
Arizona State University

Christopher Oveis
University of California, San Diego

Dacher Keltner
University of California, Berkeley

Compassion is an affective response to another's suffering and a catalyst of prosocial behavior. In the present studies, we explore the peripheral physiological changes associated with the experience of compassion. Guided by long-standing theoretical claims, we propose that compassion is associated with activation in the parasympathetic autonomic nervous system through the vagus nerve. Across 4 studies, participants witnessed others suffer while we recorded physiological measures, including heart rate, respiration, skin conductance, and a measure of vagal activity called *respiratory sinus arrhythmia* (RSA). Participants exhibited greater RSA during the compassion induction compared with a neutral control (Study 1), another positive emotion (Study 2), and a prosocial emotion lacking appraisals of another person's suffering (Study 3). Greater RSA during the experience of compassion compared with the neutral or control emotion was often accompanied by lower heart rate and respiration but no difference in skin conductance. In Study 4, increases in RSA during compassion positively predicted an established composite of compassion-related words, continuous self-reports of compassion, and nonverbal displays of compassion. Compassion, a core affective component of empathy and prosociality, is associated with heightened parasympathetic activity.

Keywords: emotion, physiology, prosociality

Suffering is a defining experience in human social life. The suffering of others evokes strong affective responses in observers. These emotions include feelings of distress, empathic pain, and—most prototypically—compassion (Batson, Fultz, & Schoenrade, 1987; Eisenberg et al., 1989; Goetz, Keltner, & Simon-Thomas, 2010). We define *compassion* as feeling sorrow or concern for the suffering of another person coupled with the desire to alleviate that suffering (Eisenberg et al., 2007; Haidt, 2003; for definitions of compassion, see Goetz et al., 2010).[1] Compassion is elicited in response to observations of different kinds of suffering, including illness (Batson et al., 1997; Stellar, Manzo, Kraus, & Keltner, 2012), disability (Eisenberg et al., 1988), starvation, and poverty (Oveis, Horberg, & Keltner, 2010). Although compassion has negative and distressing antecedents, it is considered a positive emotion that generates positive outcomes and is associated with feelings of warmth, tenderness, and soft-heartedness (Batson et al., 1997; Shaver, Schwartz, Kirson, & O'Connor, 1987). Compassion encourages a stronger connection with the sufferer by promoting greater perceptions of similarity (Oveis et al., 2010; Valdesolo & Desteno, 2011) and motivates prosocial behaviors oriented toward the reduction of need and suffering (Eisenberg & Miller, 1987). Evidence suggests that the experience of compassion may benefit well-being and health over the long term (Kok et al., 2013; Steffen & Masters, 2005). Within these theoretical analyses and findings, compassion is considered a foundational prosocial emotion that motivates caretaking, support giving, and helping behavior (Eisenberg & Miller, 1987; Nussbaum, 2003).

This emerging empirical literature on compassion dovetails with earlier theoretical claims found within evolutionary approaches. There, it has been posited that compassion originally evolved to motivate caretaking behavior directed toward offspring (Goetz et

This article was published Online First January 26, 2015.

Jennifer E. Stellar, Rotman School of Management, University of Toronto; Adam Cohen, Department of Psychology, Arizona State University; Christopher Oveis, Rady School of Management and Strategy, University of California, San Diego; Dacher Keltner, Department of Psychology, University of California, Berkeley.

Jennifer E. Stellar is now at the Department of Psychology, University of California, Berkeley.

This research was supported by the Greater Good Science Center (University of California, Berkeley). We thank Iris Mauss and Robb Willer for their insightful comments and advice.

Correspondence concerning this article should be addressed to Jennifer E. Stellar, Department of Psychology, University of California, Berkeley, Berkeley, CA 94720. E-mail: jstellar@gmail.com

[1] Batson has typically used the term *empathic concern*, which refers to a composite of emotions that include feeling sympathy, compassion, moved, and soft-hearted), and Eisenberg has used the term *sympathy*. We believe that these terms represent the same construct as compassion (for a review, see Stellar & Keltner, 2014). Therefore, we use the term compassion to refer to sympathy and empathic concern.

Journal of Personality and Social Psychology, 2015, Vol. 108, No. 4, 572–585

http://dx.doi.org/10.1037/pspi0000010

al., 2010). In support of this argument, individuals report strong compassion responses to children (Oveis et al., 2010; Zahn-Waxler, Friedman, & Cummings, 1983) and, in keeping with ideas of inclusive fitness, individuals who are closely related (Cialdini, Brown, Lewis, Luce, & Neuberg, 1997). Batson, Lishner, Cook, and Sawyer (2005) found that, to some extent, compassion is driven by nurturant tendencies toward strangers, which likely have their roots in motivations to care for offspring. Compassion has also been linked to the security of an individual's attachment style, which itself is a critical part of caregiving behavior (Mikulincer & Shaver, 2005). It is further reasoned within this evolutionary framework that compassion is extended to nonkin to encourage sacrifice and generosity and is a foundation of reciprocally beneficial relationships (Trivers, 1971). Across these relationship contexts, it is thought that compassion in response to suffering, especially emotional suffering, promotes behavioral responses aimed at soothing, calming, or caring for the sufferer.

In keeping with the caretaking origins of compassion and the types of behaviors it motivates, in the present investigation, we tested the hypothesis that compassion will be accompanied by greater parasympathetic activity than will neutral states or closely related positive and prosocial states. We measured parasympathetic activity via the vagus nerve, which we operationalized as respiratory sinus arrhythmia (RSA). This hypothesis has its precedent in theoretical arguments about the evolution of the vagus nerve (Porges, 2001) and was anticipated by select findings, to which we now turn.

Vagus Nerve: Anatomy, Measurement, and Function

The vagus nerve, the 10th cranial nerve, is a component of the parasympathetic branch of the autonomic nervous system (Beauchaine, 2001). In contrast to the sympathetic autonomic nervous system, which is associated with high-arousal negative states, the parasympathetic autonomic nervous system (PANS) more generally is thought to be responsible for activities during states of rest. The vagus nerve, one branch of the PANS, extends from the brain stem and innervates major muscles in the larynx, pharynx, and palate before traveling down to innervate the heart and digestive organs. Recent research suggests that the vagus nerve also functions to control immune response by regulating cytokine production (Rosas-Ballina et al., 2011).

Vagal activity is primarily measured through its inhibitory influence on the sinoatrial node, or pacemaker, of the heart. To obtain a noninvasive index of vagal activity, researchers can gather measures of RSA, which quantifies the degree of vagal control over the heart. During inhalation, vagus nerve activity is suppressed, resulting in heart rate acceleration; during exhalation, vagus nerve activity increases, leading to heart rate deceleration. RSA is the variability in heart rate that is specifically associated with the respiration cycle, and, thus, RSA is thought to be an indicator of vagal activity (Berntson, Cacioppo, & Quigley, 1993).

Compassion and Vagal Activity: Theoretical Claims and Suggestive Empirical Support

A conceptual analysis of compassion and empirical studies of RSA point to three reasons why compassion should be associated with greater RSA. Compassion and RSA both relate to (a) tendencies toward social connection and engagement with others; (b) prosocial motivations to care for and help others; and (c) the downregulation of negative emotions like distress, which in the case of compassion are triggered by appraisals of suffering (Batson et al., 1987; Eisenberg et al., 1989). Alongside this appraisal-based analysis that highlights the similarity in the processes underlying compassion and vagal activity, we cite suggestive evidence from physiological studies of compassion and heart rate (e.g., Eisenberg et al., 1991) and research on a closely related emotion, sadness (e.g., Marsh, Beauchaine, & Williams, 2008). These findings lend preliminary, although indirect, support to the hypothesis tested here, that compassion is associated with greater vagal activity than appropriate comparison conditions.

Compassion is a social emotion that encourages engagement behaviors and approach motivations aimed at enhancing the welfare of the sufferer (Goetz et al., 2010). Theoretical work posits that the myelinated portion of the vagus nerve, which originates in the nucleus ambiguous, facilitates social engagement (Porges, 2007). Porges's polyvagal theory claims that this portion of the vagus nerve emerged during the evolution of mammals and helps facilitate mammalian affiliative social behaviors (for analysis of the phylogenetic development of autonomic nervous systems, see Porges, 2001, 2007; for a broader summary of prosocial physiology, see Keltner, Kogan, Piff, & Saturn, 2014). Specifically, increases in vagal activity slow the heart and are argued to produce calm states that encourage social engagement and bonding with others. Anatomically, the ventral vagus interacts with neural pathways critical to social communication and engagement behaviors. These pathways innervate facial muscles required for emotional expression, such as the muscles involved in nodding the head (a behavior strongly associated with perceptions of social engagement with others; see Kogan, Impett, Oveis, van der Löwe, & Keltner, 2014; Porges, 2001); those that orient the head and gaze toward others; the laryngeal and pharyngeal muscles, responsible for talking and vocalizing; and the part of the middle ear that extracts the human voice from other sounds in the environment (Porges, 2001).

In support of this claim, resting RSA is positively associated with social engagement and connection with others. Resting RSA positively predicts the frequency of social support seeking, perceptions of social acceptance, and reports of social integration (Geisler, Kubiak, Siewert, & Weber, 2013). Individuals with higher resting RSA at the beginning of a 9-week longitudinal study reported greater social connectedness to others; in this same study, increases in reports of social connectedness over the course of the study correlated with increases in resting RSA, controlling for RSA at the beginning of the study (Kok & Fredrickson, 2010). *Vagal flexibility*, defined as higher resting vagal tone and greater vagal withdrawal during challenging tasks, is associated with greater empathic accuracy and social sensitivity (Muhtadie, Koslov, Akinola, & Mendes, in press). Alongside these findings, research with clinical samples has demonstrated that individuals diagnosed with autism, characterized by deficits in social communication and engagement with others, show lower baseline RSA than do healthy controls (Ming, Julu, Brimacombe, Connor, & Daniels, 2005; Porges, 2007). These findings suggest that greater vagal activity would accompany compassion, an emotion that functions to increase social engagement behaviors.

Empirical studies have demonstrated that resting RSA is associated with greater prosocial traits and behaviors, which form a core component of compassion (e.g., Fabes, Eisenberg, & Eisenbud, 1993; Oveis et al., 2009). Resting RSA is positively correlated with dispositional levels of sympathy (Fabes et al., 1993) and self-report measures of the trait agreeableness, a facet of personality associated with a tendency toward compassion and cooperation (Oveis et al., 2009). Individual differences in vagal activity have been associated with prosocial traits and observer perceptions of prosociality, though in these studies moderate rather than very high levels of resting vagal activity predicted the greatest prosociality (Kogan, Oveis, et al., 2014). In addition, boys in kindergarten through sixth grade with higher RSA were perceived to be more prosocial, as evidenced by peer ratings (Eisenberg et al., 1996) and teacher ratings (Eisenberg et al., 1995). In specific contexts, higher resting RSA predicts increased prosocial responses. Baseline RSA was associated with children's self-reports of sympathy in response to a film about another child in distress (Fabes et al., 1993). In discussions between mothers and adolescents, adolescents with high resting RSA showed greater empathy, measured through accuracy in judging their mothers' emotions and shared emotion (Diamond, Fagundes, & Butterworth, 2012). Although these studies measured resting RSA, they provide indirect evidence for claims that participants should experience greater RSA during a key prosocial emotion, compassion.

Compassion also involves appraisals of another's suffering and distress. Compassion may require individuals to downregulate their own negative emotions and distress, which hinder the experience of compassion (Batson et al., 1987; Eisenberg et al., 1989). Temporary increases in vagal activity have been associated with calming of the body and regulating of negative affect, quite similar to that theorized to be involved in compassion (e.g., Rockliff, Gilbert, McEwan, Lightman & Glover, 2008). For example, participants instructed to suppress or reappraise their emotional responses while describing a disgusting film clip to another participant showed larger increases in RSA than did those who regulated their responses to a neutral film clip or individuals instructed not to regulate their emotions (Butler, Wilhelm, & Gross, 2006). In the still face paradigm, mothers instructed to downregulate their emotional expression while their infants expressed distress showed an increase in RSA compared with a baseline in which infants played with a toy (Oppenheimer, Measelle, Laurent, & Ablow, 2013). And, finally, participants show greater RSA when doing calming meditation practices compared with a control condition (Ditto, Eclache, & Goldman, 2006; Krygier et al., 2013). Taken together, these results suggest that increases in RSA may be tied to the process of self-soothing or downregulation of negative affect, allowing individuals to respond to others' suffering with compassion and approach-related behaviors.

In addition to our conceptual analysis, further evidence germane to our prediction is found in patterns of heart rate deceleration, which occurs during compassion (Eisenberg et al., 1989; Stellar et al., 2012). The vagus nerve functions to inhibit the sinoatrial node of the heart, so increases in vagal activity often result in measurable decreases in heart rate (Berntson et al., 1993). Eisenberg et al. (1991) have documented that subjective reports and expressive displays of compassion covary with heart rate deceleration. Participants induced to feel compassion show decreases in heart rate compared with neutral state inductions, and the magnitude of this physiological response distinguishes between those who report more or less compassion (Stellar et al., 2012). It is important to note that this evidence must be interpreted carefully, because heart rate is affected by both the parasympathetic and sympathetic systems, highlighting the importance of measuring RSA, the focus of the present four studies.

Finally, studies of sadness, an emotion closely related to compassion, further suggest a link between RSA and compassion. In contexts in which another person is suffering, we find that sadness is correlated highly with compassion ($r = .69$ on average in the four studies presented here). In these cases, sadness is likely part of a larger family of compassion-related emotions representing concern at the plight of others (see, e.g., Goetz et al., 2010). Unlike other negative emotions, which are associated with reduced RSA, sadness shows the opposite pattern of RSA activity (e.g., Marsh et al., 2008). In studies of sadness in which participants watched video clips of vulnerable individuals suffering, participants exhibited greater parasympathetic activity and heart rate deceleration, markedly so during crying (Hendriks, Rottenberg, & Vingerhoets, 2007; Marsh et al., 2008; Rash & Prkachin, 2013; Rottenberg, Wilhelm, Gross, & Gotlib, 2003; Tsai, Levenson, & Carstensen, 2000). It is important to note, though, that some researchers have documented reduced RSA during sadness (Rottenberg, Salomon, Gross & Gotlib, 2005) or have found no RSA-related shifts during the experience of this emotion (Rainville, Bechara, Naqvi, & Damasio, 2006). In many of these studies, the stimuli depicted others suffering and, in effect, were about other-oriented sadness, raising the possibility that compassion may have triggered the observed changes in vagal activity. Taken together, this theoretical and empirical work lends credence to the hypothesis that the experience of compassion in response to suffering will be associated with greater parasympathetic activity compared with other states.

Present Research

In the present research, we sought to document whether compassion in response to suffering is associated with greater parasympathetic activity via the vagus nerve. Our work was guided by conceptualizations of emotions as brief, distinct responses that are centered on core appraisals (Ekman, 1992; Keltner, Oatley, & Jenkins, 2013). We thus ensured that our measurement of vagal activity was tied to the momentary experience of compassion. We measured vagal activity during the presentation of emotion-eliciting stimuli rather than during a baseline or affectively laden task not designed to elicit a specific emotion (e.g., a public speaking task). We also presented our stimuli for short periods, from 2 to 4 min on average, to capture the rapid onset and brief duration of the typical emotional experience.

In this sort of work, it is critical to compare the emotion of interest to conceptually relevant states (Horberg, Oveis, & Keltner, 2011; Keltner & Lerner, 2010; Oveis et al., 2010). This kind of stringent comparison allows for stronger inferences about distinct response profiles of discrete emotions. To ascertain the degree to which compassion is uniquely associated with greater vagal activity, we compared vagal activity during compassion to vagal activity during another positive emotion and a prosocial state lacking in the motivation to care and ameliorate the suffering of others. This pitted our hypothesis against two alternatives: that vagal activity is greater during positively valenced states or during prosocial emotions more generally.

In Study 1, we compared RSA during a compassion induction, in which targets discussed the death of their grandfather, to a nonemotional baseline. We aimed, in Study 2, to eliminate the alternative explanation that RSA would be greater during positive emotions more generally by comparing levels of RSA for compassion and pride. In Study 3, we ascertained whether compassion would elicit greater RSA than another prosocial emotion, inspiration. Across the first three studies, we assessed the relationship between retrospective self-reports of compassion and differences in RSA between the compassion and comparison inductions. In Study 4, we examined whether changes in RSA from a neutral to compassion induction were associated with an established composite of compassion-related emotions (Batson et al., 1997) reported by participants after the compassion induction, continuous self-report measures of compassion, and coders' perceptions of participants' verbal and nonverbal expressions of compassion during the compassion induction. Given the literature linking resting RSA with compassion, we also examined whether RSA during our neutral state inductions predicted self-reports of compassion or differences in RSA between emotion conditions or whether RSA during the neutral inductions interacted with differences in RSA between conditions to predict self-reported compassion.

Study 1

Study 1 primarily aimed to demonstrate that (a) inducing compassion by showing others who are suffering elicits greater RSA than does a nonemotional control, and (b) differences in RSA between the compassion and neutral state inductions predict self-reports of compassion. We also explored whether RSA during the nonemotional control predicted any of our measures. We measured and controlled for individual differences in social desirability, because self-reports of compassion are likely to be influenced by self-presentation concerns that could obscure the relationship between the experience of compassion and RSA.

Method

Participants. Fifty-one (20 male, 31 female) undergraduates from a large west coast U.S. university participated in this study for credit in a psychology course.

Procedure. Participants arrived in the lab one at a time, were brought into an experiment room, and physiological sensors were applied. Participants were given 15 min to report demographics and fill out a measure of social desirability. This time also allowed participants to acclimate to wearing the physiological recording devices.

For our compassion induction, participants watched a 4-min video of a female student discussing the death of her grandfather. Participants were told that the target in the video was a participant from a previous study, but in reality she was a confederate who had memorized a script created by the experimenter. The discussion focused on her grief and how she coped with the news of learning of her grandfather's death. In addition to compassion, participants were asked after viewing the video to report on how much they felt 14 other emotions during the video presentation (afraid/scared, angry, annoyed/irritated, anxious, contemptuous/disdainful, enthusiastic/excited, disgusted/revolted, happy/joyful, inspired/impressed, relaxed/comfortable, sad, surprised/shocked, trusting, and warm/tender) on a 10-point Likert-type scale from 1 (*not at all*) to 10 (*as much as I have ever felt*). After 10 min of filler tasks for another study, participants watched another 4-min video of the student recounting a nature documentary, which was also created by the experimenter and acted as the neutral, nonemotional comparison condition.

Physiological measures. In order to measure heart rate, electrocardiogram (ECG) recordings were sampled at 1 kHz and gathered over the entire 4 min of each emotion induction. Sensors were applied to the skin in a Lead II configuration to gather ECG signals. Physiological signals were collected using the MP 150 data acquisition and analysis systems (BIOPAC Systems, Inc., Goleta, CA). ECG signals were converted to beats per min to obtain heart rate and aggregated to form mean heart rate scores for the entire 4 min and the initial min and a half of the stimuli introduction. Artifacts in the signal (e.g., due to coughing, sneezing, movement) were corrected manually; this was done to less than 5% of all data files.

A respiration belt was placed on the torso to assess respiration frequency. Respiration signals were filtered directly as they were recorded with a low-pass filter of 1 Hz and high-pass filter of .05 Hz. A continuous measure of respiration rate was then obtained by transforming the data through the BIOPAC data-acquisition program to breaths per min. Respiration rate was then aggregated to form mean values over the 4 min and initial min and a half of each video.

RSA was calculated using BIOPAC's AcqKnowledge 4.0, which uses the peak-to-trough method (Grossman, van Beek, & Wientjes, 1990) to calculate RSA. This method scans the interbeat interval channel for the minimum and maximum R wave to R wave (RR) intervals during each respiration cycle. The average data were aggregated to form a mean over the 4 min and the initial min and a half of the stimulus presentation.

Individual difference measures. The Marlow and Crowne Social Desirability Scale (Crowne & Marlowe, 1960) is a 33-item scale in which participants respond either true or false, to statements such as "I have never deliberately said something that hurt someone's feelings" and "There have been times when I was quite jealous of the good fortune of others." The scale assesses how willing participants are to answer these questions truthfully or to lie in an effort to manage their self-presentation. As a result, participants were given a total score of how susceptible they were to social desirability concerns.

Results and Discussion

To ensure that our compassion stimuli reliably elicited our target emotion, we analyzed subjective reports of participants' emotions. Participants exhibited high levels of compassion in response to the student coping with the death of her grandfather ($M = 7.20$, $SD = 1.61$). Participants reported significantly more compassion than the next two most highly elicited emotions, which were sadness, ($M = 6.29$, $SD = 2.34$), $t(50) = 3.93$, $p < .001$, and warmth/tenderness, ($M = 5.37$, $SD = 2.38$), $t(50) = 7.29$, $p < .001$, which were the only two emotions with average self-reports greater than the midpoint of the scale.

We used a linear mixed-model approach that treated the type of video (neutral or compassion inducing) as a within-subject factor.

This statistical analysis allowed us to calculate differences in physiological activity within the same person over multiple emotion inductions while controlling for dependencies in the same person's data across time. Linear mixed models also allowed for the inclusion of respiration as a changing covariate, which was important, because respiratory rate was different for each emotion induction. RSA was significantly higher during the compassion condition (M = 79.06 ms, SD = 25.59 ms) than the neutral condition (M = 69.40 ms, SD = 34.30 ms), $F(1, 50) = 7.12$, p = .01, d = 0.39. Emotions are rapid in onset and brief in duration (Ekman, 1992). Therefore, we also examined the first min and a half of RSA (the shortest acceptable duration to analyze RSA; Berntson et al., 1993) because we anticipated that participant's reactions to the compassion induction would be the strongest on initially encountering the target's suffering. We found that our effects were amplified when we examined this initial 1.5 min. RSA was significantly higher in the compassion condition (M = 82.34 ms, SD = 34.02 ms) than the neutral condition (M = 70.16 ms, SD = 26.24 ms), $F(1, 50) = 12.43$, p = .001, d = 0.51.[2] Compassion-inducing stimuli elicited greater RSA than a nonemotional condition, and these effects were more pronounced in the initial stages of the stimulus presentation.

When measuring RSA, the question of whether respiration rate should be statistically controlled is debated. Some researchers argue that respiration rate, or changes in respiration rate, have a negligible impact when measuring RSA (Denver, Reed, & Porges, 2007). Others note that decreases in respiration rate increase RSA but do not change vagal activity. This claim calls into question the validity of RSA as an index of vagal activity and suggests that respiration rate should be included in all analyses as a covariate (Grossman & Taylor, 2007). Respiration rate was lower over the entire 4 min of the compassion video (M = 18.33, SD = 4.70) than it was in the neutral condition (M = 19.33, SD = 4.43), $F(1, 50)$ = 7.79, p = .007; d = 0.40. We conducted a mixed model with type of video as a within-subject factor and respiration rate as a changing covariate and still found that RSA was significantly higher in the compassion condition than in the neutral condition over the entire 4 min, $F(1, 53) = 4.61$, p = .04. Within the 1st minute and a half of the video, there were no significant differences in respiration rate between the neutral (M = 19.23, SD = 3.78) and compassion conditions (M = 18.18, SD = 4.87), $F(1, 50) = 2.67$, p = .11. Nevertheless, when we treated respiration rate as a covariate, we still observed that RSA was significantly higher in the compassion condition than in the neutral condition, $F(1, 51)$ = 9.61, p = .003. Surprisingly, we did not find significant differences in heart rate, which often accompany compassionate responses, during the compassion condition (M = 79.11, SD = 8.54) compared with the neutral condition (M = 78.37, SD = 8.31), $F(1, 50) = 2.80$, p = .10. Overall, we found a pattern of greater RSA during the compassion induction compared with a nonemotional control. As we predicted, these effects were more pronounced in the 1st minute and a half of the video, during which individuals first encountered the suffering.

We examined whether differences in RSA between the two conditions would predict self-reports of the experience of compassion. We controlled for RSA during the neutral film clip to isolate the unique effect of greater RSA in the compassion condition compared with the neutral condition on reported compassion, independent of RSA during the neutral clip. Contrary to expectations, differences in RSA between the two conditions (over the entire 4 min and the first 1.5 min), controlling for respiration rate and RSA during the neutral video, did not predict self-reports of compassion ($\beta s \leq -.11$, $ps \geq$ .44). Including social desirability as a covariate did not strengthen these correlations ($\beta s < -.10$, $ps \geq .50$).[3]

Given that past research has found a relationship between resting RSA and compassion, we also tested whether RSA during the neutral video, our closest approximation to resting RSA, predicted self-reported compassion. We found that it did not predict self-reports of compassion ($\beta = -.12$, p = .44), nor did it predict differences in RSA from the neutral to the compassion condition ($\beta = -.02$, p = .88). RSA during the neutral clip did not interact with our difference score of RSA to predict self-reports of compassion (β = .14, p = .30). Therefore, resting RSA did not predict emotional reports or physiological responses to the compassion clip or interact with differences in RSA to predict emotional responses.

Study 2

Study 1 provided support that compassion in response to suffering elicits greater vagal activity. Study 2 aimed to demonstrate that this result is specific to compassion and not to positively valenced emotions more generally. Past work has demonstrated that greater resting RSA is associated with greater positive mood and dispositional optimism (Oveis et al., 2009). Some studies have found reductions in RSA in response to positive film clips (e.g., Frazier, Strauss, & Steinhauer, 2004), although others have found slight increases or no changes at all (e.g., Demaree et al., 2006). In light of these findings and the aim of the present investigation, we chose to compare the influence of compassion and pride on RSA (for similar rationale, see Oveis et al., 2010). Compassion and pride vary on an important appraisal domain of self- versus other focus that we believe may be important for vagal activity. Compassion is elicited by suffering, characterized by appraisals of need, vulnerability, and weakness, and it promotes motivations to approach, care for, and soothe others. Pride, conversely, is a self-focused emotion that centers on appraisals of one's own strength and exceptionalism (Tracy & Robins, 2007). It is elicited when individuals feel responsible for a positive outcome and is characterized by appraisals of personal achievement and feelings of dissimilarity from vulnerable others, promoting a desire to distance oneself from weak others (Fabes et al., 1993). We anticipated that the self-focused and disengaged nature of pride would result in lower RSA during this emotion than during the compassion condition, despite pride's positive valence. In addition, we used slides to elicit our target emotions to ensure that our effects would generalize to other forms of emotionally evocative stimuli. In Study 2, we also randomized the order of the film clip presen-

[2] We also examined differences in RSA between conditions using repeated measures and found that our results in this and all subsequent studies exhibited the same pattern of significance as when analyzed using linear mixed models ($Fs \geq 3.85$, $ps \geq 05$).

[3] In this study, differences in RSA negatively predicted reports of disgust ($\beta s = -.42$, p = .003). Across all four studies, no other emotions were predicted by RSA besides the target emotions when correcting for testing multiple relationships using a family-wise Bonferroni correction ($p < .007$). Therefore, we do not believe that RSA reliably predicts the experience of other discrete emotions in response to suffering.

tation to account for potential order effects that may have affected the results of Study 1, in which the order was not counterbalanced. We hypothesized that the experience of compassion would elicit greater RSA than pride or a neutral comparison condition.

Method

Participants. Eighty-one (19 male, 61 female, one decline to state) undergraduates participated in this study for credit in a psychology course.

Procedure. Participants arrived in the lab one at a time and were brought into an experiment room where physiological sensors were applied. Participants were shown three sets of slides (Oveis et al., 2009, 2010) that elicited no emotion, compassion, and pride while they were connected to the physiological recording devices. Each set of slides was 1.5 min in duration, and the order of presentation of the compassion and pride slides was randomized. Neutral slides showed different shapes and numbers, compassion slides included photographs of individuals who were suffering (starving children, homeless individuals, injured animals, crying babies, etc.), and pride slides included photographs of the students' university and of national symbols. After watching each set of slides, participants reported on the intensity of their experience of compassion and pride along with six other emotions (anger, awe, enthusiasm/excitement, fear, sadness, and surprise) on a Likert-type scale of ranging from 0 (*not at all*) to 10 (*as much as I have ever felt*).

Physiological measures. Heart rate was measured by collecting ECG recordings from an ambulatory monitoring system (VU-AMS, Amsterdam, the Netherlands). ECG recordings were gathered by applying sensors to the skin in a Lead II configuration. Recordings were sampled at 1 kHz and were gathered over the 1.5 min of the emotion induction. Artifacts in the signal (e.g., due to coughing, sneezing, movement) were corrected manually; this was done to less than 5% of all data files.

Vagal activity was computed by using cardiac metric software (CMet; Allen, Chambers, & Towers, 2007) as we did not have measures of respiration frequency. The analysis was based on Porges' adaptive polynomial filter method, in which a series of interbeat intervals is filtered through a high-frequency band. CMet calculates RSA by taking a series of interbeat intervals and filtering them using a frequency band (Allen et al., 2007). This program offers a validated analysis of RSA that correlates highly with measures from other established programs such as Mxedit while reducing the effects of potential human error (Allen et al., 2007). RR intervals from the ECG channel over the 1.5 min of each induction were passed through a high-frequency spectrum range (0.12–0.40 Hz) and logged to isolate the activity of the vagus nerve.

Results and Discussion

First, we aimed to establish that our neutral induction was in fact a nonemotional comparison condition. Across all eight emotions, participants reported ratings of 1.28 ($SD = 0.80$) within a possible range of 0 (*not at all*) to 10 (*as much as I have ever felt*). These findings support the claim that our induction did not elicit any strong emotions.[4] Second, we aimed to establish that our emotion manipulations elicited the target emotions of interest. Participants reported significantly higher levels of compassion toward the compassion-eliciting slides ($M = 6.31$, $SD = 1.83$) than the pride slides ($M = 2.09$, $SD = 2.13$), $t(76) = 13.04$, $p < .001$. In addition, the pride slides evoked significantly more pride ($M = 5.38$, $SD = 2.52$) than the compassion slides ($M = 0.55$, $SD = 1.09$), $t(76) = 11.19$, $p < .001$. Compassion was also the highest rated emotion in response to the slides depicting suffering and the only emotion, other than sadness ($M = 6.08$, $SD = 1.74$), that was elicited at higher levels than the midpoint of the scale.

For three participants, physiological responses were not recorded properly and were excluded from analysis. In a linear mixed-models analysis of our main variable of interest, participants showed greater RSA activity while watching the compassion-inducing slides ($M = 6.22$, $SD = 1.05$) than while watching the pride-inducing slides ($M = 6.05$, $SD = 1.02$), $F(1, 78) = 4.52$, $p = .04$, $d = 0.39$ (see Figure 1) or the neutral slides ($M = 6.03$, $SD = 1.08$), $F(1, 78) = 5.29$, $p = .02$, $d = 0.28$. In addition, participants showed lower heart rate while watching the compassion-inducing slides ($M = 77.72$, $SD = 10.96$) than while watching the pride-inducing slides ($M = 80.99$, $SD = 11.60$), $F(1, 78) = 33.70$, $p < .001$, $d = 0.65$, or the neutral slides ($M = 80.07$, $SD = 11.07$), $F(1, 78) = 33.34$, $p < .001$, $d = 0.67$.

Differences in RSA during the compassion slides, controlling for RSA during the neutral slides, did not predict self-reported compassion ($\beta = -.12$, $p = 35$). In this study, RSA during the neutral video was a significant predictor of self-reports of compassion ($\beta = 23$, $p = .05$), and differences in RSA from the neutral to the compassion condition ($\beta = -.38$, $p = .001$) but did not interact with differences in RSA to predict self-reports of compassion ($\beta = -.04$, $p = .97$). These results suggest that more trait-like RSA activity during the neutral induction predicts emotion reports and physiological responses to the compassion slides in keeping with previous studies (e.g., Oveis et al., 2009). Overall, we found that the experience of compassion elicited greater RSA and lower heart rate compared with the experience of pride.

Study 3

In Study 3, we compared RSA during compassion with another prosocial emotion that lacks appraisals of suffering—inspiration. Inspiration, along with compassion, is part of a family of prosocial emotions that promote social engagement (Algoe & Haidt, 2009). Inspiration is typically elicited by artistic and scientific insight, finding a purpose in life, and being around role models, and it generates feelings of transcendence and the urge for self-improvement (Algoe & Haidt, 2009; Thrash & Elliot, 2003). Given that resting levels of RSA predict prosocial states, it is possible that RSA may be a marker of prosocial emotions more broadly (Oveis et al., 2009; Porges, 2001). No study to date had sought to distinguish which prosocial states RSA is associated with; a comparison of compassion and inspiration represented a theoretically grounded first step in addressing this conceptual concern. We hypothesized that suffering and the motivation to downregulate negative emotions and care for the sufferer may be critical to eliciting higher RSA during compassion. Compassion, unlike in-

[4] In a pilot sample ($n = 26$), participants recruited from Amazon Mechanical Turk (https://www.mturk.com/) rated each neutral slide from 1 (*not neutral at all*) to 5 (*completely neutral*). Participants reported that these slides were almost completely neutral ($M = 4.24$, $SD = .69$).

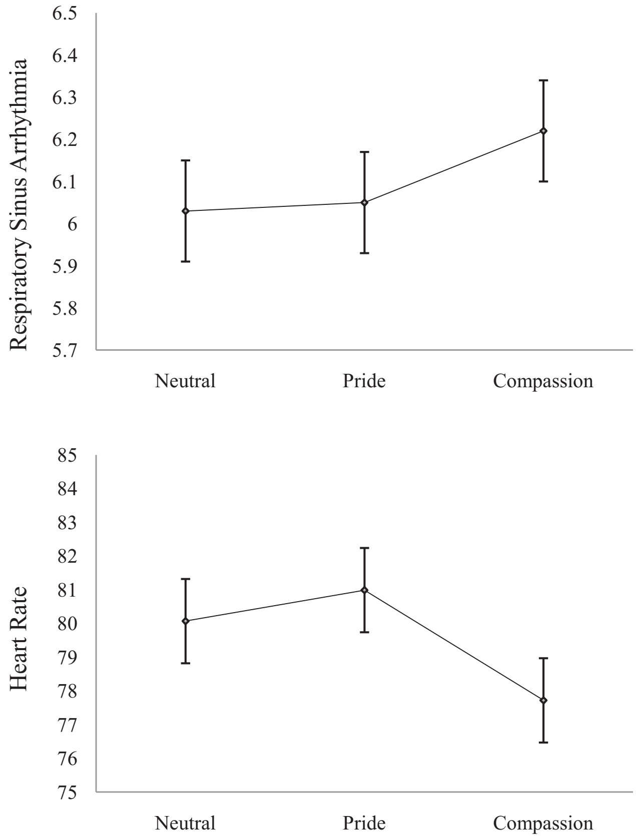

Figure 1. Mean levels of RSA and HR during the neutral, pride and compassion conditions.

spiration, is elicited by the suffering of others, which is theorized to entail the downregulation of distress and negative emotion to orient and respond to others' needs (Batson et al., 1987). Downregulation of negative emotions and the soothing affective system appear to be central to increased RSA (e.g., Butler et al., 2006; Van Kleef et al., 2008). Inspiration is not typically elicited by suffering or weak others but by individuals who demonstrate exceptionalism (Algoe & Haidt, 2009; Thrash & Elliot, 2003). Therefore, it does not typically require any downregulation of distress, nor is it oriented toward caring for those in need, both reasons to hypothesize that inspiration may be associated with lower RSA than compassion. An additional reason to compare compassion with inspiration is that the latter state is often reported during compassion, and both emotions are associated with warmth and tenderness and trigger approach motivations (Algoe & Haidt, 2009). As a result, comparing compassion with inspiration allowed us to further isolate the relationship between compassion and RSA.

We also collected an additional physiological measure, skin conductance level (SCL). SCL has been shown to index general emotional arousal (Cuthbert, Bradley, & Lang, 1996), stress (Dawson, Schell, & Filion, 2000), and perceptions of threat (Mathews, Richards, & Eysenck, 1989). SCL is a purely sympathetic measure and allowed us to monitor sympathetic arousal during our compassion inductions, enabling us to solidify our claim that compassion is associated with greater parasympathetic activity than comparison conditions and identify whether our compassion inductions were evoking stress, threat, or other forms of negative emotional arousal. We predicted that RSA would be higher during the compassion-inducing film clip than the neutral or inspiration film clips, but that SCL would not differ across conditions.

Method

Participants. Seventy-four (33 male, 41 female) undergraduates participated in this study for credit in a psychology course.

Procedure. Participants arrived in the lab individually, were seated in front of a computer, and physiological sensors were applied. Participants supplied demographic information on the computer and then watched three 2-min videos, which were meant to elicit compassion, elicit inspiration, or provide a nonemotional control. These videos were presented in random order and were separated by approximately 2–3 min of filler or distraction tasks in which participants had to write as many words as possible that started with a particular letter in addition to answering questions. As part of the compassion induction, participants were shown a video of children and their families who attend St. Jude's hospital, where the children were receiving treatment for cancer. This video primarily covered footage of the parents discussing when they learned their child had cancer, the chemotherapy sessions that the children attended, and the outcomes of the cancer treatment. This compassion induction has been validated as successfully eliciting compassion (Stellar et al., 2012). In the inspiration video, participants were shown a man carrying a sign saying free hugs and giving hugs to strangers on the street set to inspirational music. The neutral condition consisted of an instructional video on how to build a fence. In addition to compassion, participants were asked to list how much they experienced the same emotions as Study 1 from 1 (*not at all*) to 10 (*as much as I have ever felt*) after each video.

Physiological measures. ECG sensors were applied in a Lead II configuration, a respiration belt was placed on the participant's torso to measure the rate of inhalation and exhalation, and SCL was measured by passing a constant voltage (0.5 V) between disposable snap electrodes that were pregelled with isotonic gel and placed on the palmar surface approximately an inch apart. ECG and respiration data were gathered and cleaned for artifacts using the same methods as in Study 1, and heart rate, respiration rate, and RSA were then calculated. Physiological measures were gathered over the entire length of the emotion induction. In addition, continuous measures of unfiltered SCL signals were averaged over the entire 2 min of each video.

Results and Discussion

There were significant differences in self-reports of compassion in response to the different conditions, $F(2, 142) = 225.10$, $p < .001$, such that participants reported greater compassion during the compassion condition than during the neutral condition $F(1, 71) = 469.22$, $p < .001$, and the inspiration condition, $F(1, 72) = 65.11$, $p < .001$. However, other prosocial emotions such as warmth/tenderness, inspiration, and trust were more strongly elicited in the inspiration condition (see Table 1 for emotion comparisons).

Physiology data from one participant's session did not record properly, three participants had too many artifacts in their heart rate during the neutral condition to clean, and two participants had too many artifacts in their heart rate during the inspiration condition to clean and, therefore, we do not have RSA values for these

Table 1
Mean Levels of Emotion Self-Reports, by Condition, in Study 3

Emotion	Compassion video	Inspiration video	Neutral video
Compassion	7.04 (2.04)	4.90 (2.51)	1.34 (1.33)
Warmth	5.27 (2.80)	6.62 (2.49)	1.86 (1.62)
Inspiration	4.35 (2.61)	6.07 (2.76)	2.49 (2.11)
Trust	4.11 (1.76)	5.26 (2.49)	2.47 (2.14)

Note. Standard deviations are given in parentheses. Emotions were rated on a scale from 1 (*not at all*) to 10 (*as much as I have ever felt*). All means are significantly different by condition at $p < .001$.

participants during these video presentations. In this study, RSA was not normally distributed. Therefore, we performed a log transformation when measuring it as dependent variable. Participants showed greater RSA in the compassion condition than in the neutral, $F(1, 71) = 6.63$, $p = .01$, $d = 0.39$, or the inspiration condition, $F(1, 70) = 23.67$, $p < .001$, $d = .67$ (see Figure 2).[5] Participants also showed reduced respiration rate during the compassion condition ($M = 18.21$, $SD = 3.45$) compared with the neutral ($M = 19.06$, $SD = 5.03$), $F(1, 71) = 12.02$, $p = .001$, $d = 0.42$, and inspiration conditions ($M = 19.24$, $SD = 3.46$), $F(1, 72) = 20.68$, $p < .001$, $d = 0.52$. We found that RSA was still greater in the compassion condition than in the inspiration condition when entering respiration rate into the model as a changing covariate, $F(1, 71) = 12.02$, $p = .001$, but was no longer significantly greater than in the neutral condition, $F(1, 74) = 2.23$, $p = .14$. Heart rate was also significantly lower in the compassion condition ($M = 73.42$, $SD = 9.41$) than in the neutral ($M = 75.71$, $SD = 9.85$), $F(1, 71) = 41.57$, $p < .001$, $d = 0.81$, or inspiration conditions ($M = 74.83$, $SD = 9.43$), $F(1, 70) = 21.13$, $p < .001$, $d = 0.72$. There were no significant differences in SCL between the compassion and the neutral, $F(1, 70) = 0.06$, $p = .80$, or inspiration conditions, $F(1, 70) = 0.06$, $p = .81$.

Greater RSA during the compassion video than during the neutral video, controlling for RSA during the neutral video, did not predict participants' self-reports of compassion ($\beta = .03$, $p = .83$). RSA during the neutral video did not predict self-reports of compassion ($\beta = .13$, $p = .31$) or differences in RSA between the compassion and neutral conditions ($\beta = -.07$, $p = .56$), nor did it interact with difference scores of RSA to predict self-reports of compassion ($\beta = 0.06$, $p = .71$).

Participants showed greater RSA, lower respiration rate, and lower heart rate in the compassion condition than in the neutral or inspiration conditions, but no differences in SCL. These findings replicate the results from Study 1 and 2 suggesting that RSA is greater during the experience of compassion compared with two different positive emotions, pride and inspiration. Across the first three studies, we used a variety of different stimuli, including videos of other students, slides, and films, suggesting that our results are not bound by the nature of the stimulus but are more tightly tied to compassion.

Study 4

Three studies demonstrated that compassion-inducing stimuli are associated with greater RSA, whereas pride-inducing and inspiration-evoking stimuli are not. However, the previous studies did not yield a robust relationship between RSA and participants' self-reports of compassion. This lack of covariation between peripheral physiology and subjective experience is commonly observed in research of this kind, in particular when reports of emotion are retrospective and removed from the emotion-eliciting stimulus, as in our first three studies (Bonanno & Keltner, 2004; for a review, see Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005). Evidence related to the linkage between the experience of compassion and increased RSA is important to our general argument and motivated Study 4.

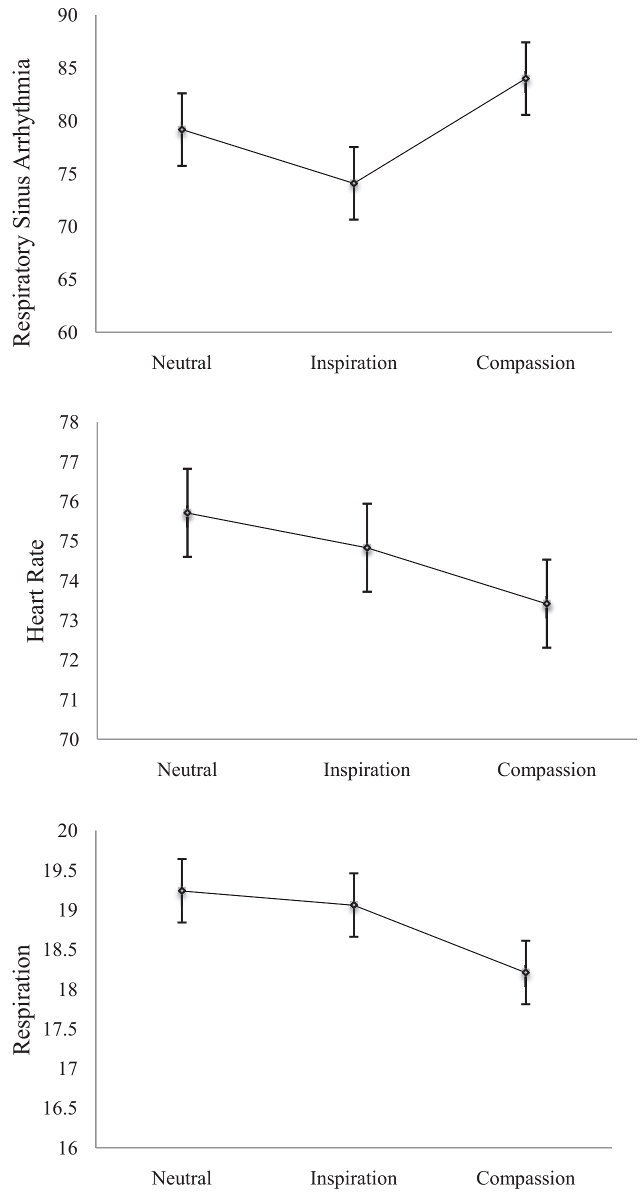

Figure 2. Mean levels of RSA, HR, and respiration during the neutral, inspiration, and compassion conditions.

[5] Analyses comparing RSA between conditions and controlling for respiration showed the same pattern of significance when using RSA values that were not log transformed, ($Fs \geq 6.08$, $ps \leq .02$, $ds \geq .19$) in Studies 3 and 4.

In Study 4, therefore, we turned to new methods to examine the compassion–RSA association. First, we broadened the items participants used to report on their emotional experience to include emotion words that have been previously associated with empathic concern, a state closely resembling compassion (Batson et al., 1997). Our previous studies relied on single-item reports of emotions, which may not have captured the full subjective experience. Second, we introduced more "online" approaches to assess subjective emotion, adapted from previous studies of emotions and physiological responses (Levenson & Gottman, 1983). Retrospective reports of emotion may not capture the more spontaneous experience of emotion, because they suffer from biases such as duration neglect and are often derived from averaging the peak and end emotional intensity of an experience (Fredrickson & Kahneman, 1993; Levine & Safer, 2002). These biases may be particularly problematic when attempting to establish a relationship with contemporaneous physiological responses. In this study, we relied on a technique pioneered by Levenson and Gottman (1983) wherein participants rewatch an emotional stimulus a second time while continuously rating with a rating dial the emotions they experienced in the original encounter with the stimulus. Third, we coded participants' expressive behavior to ascertain whether RSA might covary with compassion-related responses, measured through nonverbal displays and verbal cues (Eisenberg et al., 1989; Kogan, Impett, et al., 2014). By expanding the self-report items, relying on continuous measures of subjective emotion, and capturing expressions of compassion, we were in a much better position to document compassion–RSA associations than we were in our first three studies, which relied in single-item, retrospective self-reports.

Method

Participants. Ninety-four undergraduates (26 male, 68 female) participated in this study for credit in a psychology course.

Procedure. Participants arrived in the lab individually and were seated at a computer station in front of a mounted video camera. They were connected to the MP 150 data acquisition and analysis systems (BIOPAC Systems, Inc.) through sensors applied to their skin in the same configuration as in Study 3.

After providing information about demographics, participants first watched a neutral film clip followed immediately by a compassion-inducing clip. These clips were the same as those used in Study 3. After the compassion-inducing video, participants reported how much they felt the target emotion of compassion in addition to three other compassion-related states: *moved*, *warm/tender*, and *soft-hearted* from 1 (*not at all*) to 10 (*as much as I have ever felt*). These four emotions showed high reliability ($\alpha = .87$). They were embedded within 10 other emotions: *afraid*, *annoyed*, *angry*, *anxious*, *awed*, *contemptuous*, *disgusted*, *inspired*, *sad*, and *wondering*. The experimenter then asked participants to summarize the video clip and discuss their reaction to it out loud while the experimenter waited outside. Participants were given as much time as they wished to provide this summary.

The experimenter told participants they would be watching the same compassion-inducing video a second time, but that they would continuously report how much compassion they felt during their original viewing of the clip using a hand held sliding scale. Participants were asked to rewatch the video while making ratings of their compassion. We did not ask participants to make these rating the first time they watched the video because the movements entailed in making such ratings can introduce artifacts into physiological signals and can interfere with participants' spontaneous responses to the emotional stimulus in a first viewing (Levenson & Gottman, 1983). Participants used a sliding scale device (TSD115 Variable Assessment Transducer by BIOPAC Systems, Inc.), which provides continuous subjective responses to stimuli. The labels on the device were modified to range from 1 (*I do not feel compassion at all*) to 10 (*I feel compassion very strongly*). Once participants reported they were comfortable using the scale without looking at it, they placed it in their lap and watched the video, moving the scale in accordance with their levels of compassion. On finishing the task, they called the experimenter back into the room and were debriefed and released.

Physiological measures. Heart rate, respiration rate, SCL, and RSA were gathered in the same manner as Study 3. Continuous recordings of these measures were averaged over the entire length of the neutral and compassion film clips. Five participants produced physiology files with too many errors to use and were removed from all analyses, leaving a total sample of 89 participants.

Verbal and nonverbal expressions of compassion. Two independent coders, blind to the RSA levels of the participants, watched videos of the participants watching the compassion clip and discussing their reactions to the clip. The camera was oriented so that the videos of participants displayed their torso and head. Raters were instructed to answer two questions—"How much do you think this person felt compassion/sympathy?" and "How much do you think this person felt anxiety/distress?"—on four-point Likert-type scales; 0 (*not at all*), 1 (*a little*), 2 (*moderately*), or 3 (*very strongly*; for a similar coding system see Oveis et al., 2009).

Coders were trained to look for facial and body expressions associated with compassion, including furrowing in the center of the brow, eyebrows pulled down flat and forward, lower face relaxed with the mouth sometimes opened or frowning, head and body oriented forward and vocalizations typically associated with sympathy (Eisenberg et al., 1989; Goetz et al., 2010). Coders were instructed to provide ratings of participants' distress based on a different set of behaviors: the tightening of their lips or biting of the lip and eyebrows that were lowered and pulled forward. In addition, coders were allowed to use verbal cues of compassion when making their ratings. Coders demonstrated acceptable reliability in their perception of participants' compassion ($\alpha s \geq .81$) and distress ($\alpha s \geq .66$) while participants watched the video and discussed it.

Results and Discussion

As in Study 3, participants reported high levels of compassion in response to the compassion-inducing film clip ($M = 7.37$, $SD = 1.59$). The compassion composite ($M = 6.66$, $SD = 1.78$) made up of warm/tender ($M = 6.26$, $SD = 2.13$), moved ($M = 6.66$, $SD = 2.27$), and soft-hearted ($M = 6.38$, $SD = 2.35$) also received high ratings among participants.

One participant was removed from the analyses of RSA because he or she had an RSA value during the compassion clip that was more than 3 standard deviations from the mean, and two participants were removed from the heart rate analyses for this same reason. RSA measures were not normally distributed, so we performed a log transformation to improve the normality of the distribution when measuring RSA as a dependent variable. A linear mixed-models analysis revealed significantly higher RSA in response to the compassion video (M = 94.41, SD = 48.18) compared with the neutral video (M = 87.83, SD = 43.47), $F(1, 88) = 6.91$, $p = .010$, $d = 0.27$. There were significant differences in respiration rate between conditions, $F(1, 87) = 4.80$, $p = .03$, $d = 0.23$, with a lower respiration rate in response to the compassion video (M = 16.51, SD = 3.51) than to the neutral video (M = 16.99, SD = 3.45). Differences in RSA remained significant when controlling for respiration rate, $F(1, 81) = 6.19$, $p = .02$. There were also differences in heart rate across the conditions, $F(1, 86) = 12.61$, $p = .001$, $d = 0.37$. In the compassion condition (M = 74.68, SD = 12.00) participants showed significantly slower heart rate compared with the neutral condition (M = 75.80, SD = 12.45). There were no significant changes in SCL between the neutral (M = 9.64, SD = 5.93) and compassion conditions (M = 9.94, SD = 6.05), $F(1, 88) = 1.55$, $p = .22$. Overall, results suggest that the compassion video was associated with increased RSA and reduced heart rate and respiration rate, but not changes in SCL.

In the following analyses we examine how RSA during the compassion clip predicted our self-report and behavioral measures. In these analyses, we controlled for RSA during the neutral condition and changes in respiration rate.[6] Increases in RSA during the compassion-inducing clip did not predict self-reports of the single item, retrospective report of compassion gathered after the viewing of the video, in keeping with findings from our initial studies ($\beta = .12$, $p = .29$). RSA during the neutral video was a predictor of self-reports of compassion ($\beta = .32$, $p = .004$), although it did not predict changes in RSA ($\beta = -.07$, $p = .52$) and did not interact with changes in RSA to predict self-reported compassion ($\beta = .02$, $p = .87$). Notably, increases in RSA did predict our compassion composite of emotions ($\beta = .22$, $p = .05$; see Table 2 for all measures of emotion).

During the continuous rating task, five participants did not follow the instructions and therefore did not generate usable data. Data from participants' continuous rating of compassion during the compassion video were aggregated over the entire film clip to create a mean continuous compassion rating (M = 6.37, SD = 1.56). There was a sizable and significant correlation between this continuous measure of compassion and the retrospective reports of compassion at the end of the clip ($r = .53$, $p < .001$). Increases in RSA during the viewing of the compassion video predicted mean continuous compassion rating when rewatching the compassion video ($\beta = .26$, $p = .03$). These results suggest that increases in RSA predict reports of compassion composites and more continuous measures of compassion.

Table 2
Measures of Emotion in Study 4

Compassion measure	RSA
Single-item self-report	0.12
Composite self-report	0.22*
Continuous ratings	0.26*
Coded expression	0.24*

Note. Values represent beta coefficients, with respiratory sinus arrhythmia (RSA) predicting different methods of assessing compassion experience.
* $p < .05$.

Coded displays of compassion were calculated by averaging coders' ratings of participants' compassion during the video and while discussing it. Increases in RSA during the compassion video predicted coders' ratings of the participant's outward displays of compassion ($\beta = .24$, $p = .04$). As expected, increases in RSA did not significantly predict coders' perceptions of the participants' distress ($\beta = -.13$, $p = .26$; see Table 2).

Taken together, the results find that increases in RSA during the compassion clip were significantly associated with three measures of compassion: compassion using a validated composite of compassion-related words, continuous online ratings of compassion, and observed behavioral expressions of compassion.

General Discussion

The present investigation demonstrates that the experience of compassion, when encountering the suffering of others, leads to markedly greater vagal activity compared with neutral or other emotional states. Across four studies, we found that compassion-inducing stimuli, but not those that induce pride (Study 2) or inspiration (Study 3), were reliably associated with greater RSA. Greater RSA in response to suffering was also accompanied by lower heart rate and respiration rate in the majority of our studies but was not associated with differences in SCL. Greater RSA in the compassion than in the neutral condition and RSA during the neutral condition both failed to consistently predict single-item self-reports of compassion across our four studies. However, in Study 4, increases in RSA while encountering suffering predicted a self-report composite of compassion-focused emotions, continuous ratings of compassion during the stimulus presentation, and increased nonverbal and verbal expressions of compassion but not distress, as rated by naïve observers.

These findings add to a growing line of work supporting the claim that compassion is a distinct emotion (Gilbert, 2013; Goetz et al., 2010; Oveis et al., 2010). Compassion evolved to promote caretaking and reciprocal altruism, which are critical to human survival, suggesting that this emotion should be a universally experienced (Goetz et al., 2010; Trivers, 1971). Instances of compassion have even been identified in chimpanzees, a closely related species that also has elaborate caretaking systems (de Waal, 1996). Compassion has its own unique expression through touch (Hertenstein, Keltner, App, Bulleit, & Jaskolka, 2006) and vocalization (Simon-Thomas, Keltner, Sauter, Sinicropi-Yao, & Abramson, 2009), which distinguish it from closely related emotions such as love, sadness, and gratitude. In addition, past work has identified regions of the brain, specifically the periaqueductal gray, that are uniquely associated with the experience of compassion (Simon-Thomas et al., 2012). The present investigation's findings build on

[6] When performing regressions predicting our self-report and observed measures of compassion from differences in RSA between conditions, we did not log transform RSA. Past work suggests that independent variables should not be transformed, as a nonnormal distribution of the independent variable does not violate the assumptions of regressions, and that transforming this variable can reduce the spread of the data, making it more difficult to assess relationships between variables (McClelland, & Judd, 1993). We found that our effects held for the rating dial when log transforming differences in RSA (β =.25, p =.03), but our composite self-report (β =.16, p =.17) and coded measures (β =.17, p =.16) were reduced in significance.

these recent discoveries, offering the first evidence pointing to neurophysiological correlates of compassion in the autonomic nervous system.

The degree to which specific emotions are associated with unique physiological responses has been a source of debate since William James made the case for this possibility in the late 19th century, and it is germane to the evidence from the present investigation (James, 1884). Empirical support for such autonomic specificity has been mixed (Levenson, 2003; Mauss et al., 2005). However, advances in the measurement of physiological responses point to promising means by which emotion-specific physiological responses can be documented. For instance, proinflammatory cytokines may be related to specific submissive emotions such as shame, guilt, and fear (Dickerson, Kemeny, Aziz, Kim, & Fahey, 2004; Moons, Eisenberger, & Taylor, 2010); cortisol has been linked specifically to the experience of anger (Moons et al., 2010); and the blush, resulting from increased blood flow to the subcutaneous capillaries of the head, is readily associated with embarrassment (Cutlip & Leary, 1993; Shearn, Bergman, Hill, Abel, & Hinds, 1990). We have provided additional support for the claim that as researchers begin to use a greater number of physiological measures, physiological profiles of distinct emotions may emerge.

Our results have interesting implications for whether greater parasympathetic activity during compassion may yield health benefits or such activity may mediate the health benefits associated with compassion and prosocial behavior (Brown et al., 2009; Ludwig & Kabat-Zinn, 2008). Researchers have theorized that compassion may yield neurophysiological benefits such as increased activity in the left frontal lobes and enhanced immune function (Davidson, 2002). Practices that incorporate compassion, such as particular types of meditation and mindfulness, lead to reductions in physiological signs of stress in response to negative situations, levels of pain, and obesity and bulimia (for a review, see Ludwig & Kabat-Zinn, 2008). Building on these past findings, it is possible that compassion in response to suffering, especially in contrast to distress, may provide temporary boosts in vagal activity that compound over time to provide health benefits. The vagus nerve inhibits the hypothalamic–pituitary–adrenal axis and helps to regulate the immune response (Borovikova et al., 2000; Bueno et al., 1989). In some studies, vagal activity is even used as a marker of positive health. These studies establish that psychological experiences, such as repeated practices of loving-kindness mediation, can affect chronic vagal activity over time (Kok et al., 2013). Future work should examine whether health benefits associated with compassion may be vagally mediated.

Across the present studies, our methodological choices created some important limitations, which must be borne in mind when interpreting the results of this investigation. We chose to use a neutral activity as our comparison condition instead of a passive resting baseline. The advantage of this choice is that we eliminated confounds, such as attentional demands, that would lead to differences in RSA between a true resting baseline and a compassion induction. However, one disadvantage of using this type of neutral activity is that participants' RSA may have slightly decreased while they viewed the film clips or pictures, making it hard to determine whether RSA increased from a resting state or was merely higher than in comparison conditions. Further, we chose to counterbalance our stimulus presentation in many of the studies. As a result, our comparison conditions did not always precede our compassion inductions, which is traditionally the case when trying to identify increases in physiological activity.

In addition, our results were designed to test traditional notions about the relationship between emotion and physiology, which claim that emotions promote changes in the autonomic system to prepare the body for different behaviors (Levenson, 1992). We demonstrated that inductions of compassion reliably elicit greater RSA across four studies. However, we did not design studies that would allow us to address the reverse direction of causality—whether increases in RSA can also elicit increases in compassion. A few studies have found support for the claim that physiology can shape emotional experience (e.g., Gray, Harrison, Wiens, & Critchley, 2007). Thus, it is possible that there is a bidirectional relationship between RSA and compassion. Future work could identify whether increases in RSA increase the propensity to experience compassion by manipulating RSA through an unrelated task and measuring resulting changes in reports of compassion.

The present investigation also raises questions about the role of emotion regulation in explaining the relationship between compassion and RSA. Past work has found that individual differences in RSA reactivity are associated with better regulation (e.g., Thompson, Lewis, & Calkins, 2008). Given this, one possible interpretation of our results is that differences in RSA between conditions may actually represent a more traitlike tendency to regulate one's emotions, particularly distress, that is merely activated during compassion (Batson et al., 1987). Within our studies, we did not include a comparison condition that elicited regulation of distress that would allow us to rule out this alternative interpretation. However, to address this possibility, we examined data from a separate study of RSA during a compassion induction relative to a neutral induction and in which we also measured individual differences in emotion regulation. In these data, we found that individual differences in emotion regulation were not associated with either compassion or RSA during compassion inductions.[7] Along these lines, no studies have yet identified a relationship between individual differences in emotion regulation and compassion or RSA during the experience of compassion. Another possibility is that active regulation during compassion mediates the link between compassion and greater RSA. During the experience of compassion, individuals may be more likely to engage in emotion regulation techniques to help reduce their distress at witnessing the suffering of others. In this way, compassion may evoke greater RSA by inducing spontaneous emotion regulation. In support of this claim, studies have begun to demonstrate a relationship between emotion regulation during emotional experiences and RSA reactivity, though this work is still nascent and has not been tested during compassion (Butler et al., 2006). Future studies should more directly test the role of emotion

[7] In this study, we used a similar compassion induction and found that, as in the present research, it was associated with greater RSA during compassion relative to a neutral condition ($n = 78$). These additional data also included a measure of individual differences in emotion regulation (the Emotion Regulation Questionnaire [ERQ]; Gross & John, 2003). We found no relationship between individual differences in emotion regulation tendencies (assessed through the reappraisal and suppression subscales) and differences in RSA from the compassion to neutral induction ($\beta \leq .13$, $p \geq .21$). We also found no relationship between ERQ scores and self-reports of compassion ($\beta \leq .15$, $p \geq .11$).

regulation, either as a trait or state measure, in explaining the relationship between RSA and compassion.

Conclusion

Compassion is at the core of moral systems and fundamental to prosociality. Long the focus of philosophy and those writing within ethical and spiritual traditions (e.g., Armstrong, 2006), it is only recently that science has begun to map the different responses associated with compassion. The findings of the present investigation suggest that compassion engages a branch of the autonomic nervous system that is old in mammalian evolution and involved in social engagement and caregiving. These findings suggest that compassion has an old evolutionary past, one anticipated long ago by Charles Darwin (1872): Sympathy "will have been increased through natural selection; for those communities, which included the greatest number of the most sympathetic members, would flourish best, and rear the greatest number of offspring" (p. 130). The present data are part of an emerging interest in the physiological bases of compassion and the broader interest in the origins and functions of this emotion.

References

Algoe, S. B., & Haidt, J. (2009). Witnessing excellence in action: The "other-praising" emotions of elevation, gratitude, and admiration. *Journal of Positive Psychology, 4,* 105–127. http://dx.doi.org/10.1080/17439760802650519

Allen, J. J. B., Chambers, A. S., & Towers, D. N. (2007). The many metrics of cardiac chronotropy: A pragmatic primer and a brief comparison of metrics. *Biological Psychology, 74,* 243–262. http://dx.doi.org/10.1016/j.biopsycho.2006.08.005

Armstrong, K. (2006). *The great transformation: The beginning of our religious traditions*. New York: Knopf.

Batson, C. D., Fultz, J., & Schoenrade, P. A. (1987). Distress and empathy: Two qualitatively distinct vicarious emotions with different motivational consequences. *Journal of Personality, 55,* 19–39. http://dx.doi.org/10.1111/j.1467-6494.1987.tb00426.x

Batson, C. D., Lishner, D. A., Cook, J., & Sawyer, S. (2005). Similarity and nurturance: Two possible sources of empathy for strangers. *Basic and Applied Social Psychology, 27,* 15–25. http://dx.doi.org/10.1207/s15324834basp2701_2

Batson, C. D., Sager, K., Garst, E., Kang, M., Rubchinsky, K., & Dawson, K. (1997). Is empathy-induced helping due to self–other merging? *Journal of Personality and Social Psychology, 73,* 495–509. http://dx.doi.org/10.1037/0022-3514.73.3.495

Beauchaine, T. (2001). Vagal tone, development, and Gray's motivational theory: Toward an integrated model of autonomic nervous system functioning in psychopathology. *Development and Psychopathology, 13,* 183–214. http://dx.doi.org/10.1017/S0954579401002012

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology, 30,* 183–196. http://dx.doi.org/10.1111/j.1469-8986.1993.tb01731.x

Bonanno, G., & Keltner, D. (2004). The coherence of emotion systems: Comparing "on-line" measures of appraisal and facial expressions, and self-report. *Cognition and Emotion, 18,* 431–444. http://dx.doi.org/10.1080/02699930341000149

Borovikova, L. V., Ivanova, S., Zhang, M., Yang, H., Botchkina, G. I., Watkins, L. R., . . . Tracey, K. J. (2000, May 25). Vagus nerve stimulation attenuates the systemic inflammatory response to endotoxin. *Nature, 405,* 458–462. http://dx.doi.org/10.1038/35013070

Brown, S. L., Smith, D. M., Schulz, R., Kabeto, M. U., Ubel, P. A., Poulin, M., . . . Langa, K. M. (2009). Caregiving behavior is associated with decreased mortality risk. *Psychological Science, 20,* 488–494. http://dx.doi.org/10.1111/j.1467-9280.2009.02323.x

Bueno, L., Gue, M., Fargeas, M. J., Alvinerie, M., Junien, J. L., & Fioramonti, J. (1989). Vagally mediated inhibition of acoustic stress-induced cortisol release by orally administered kappa-opioid substances in dogs. *Endocrinology, 124,* 1788–1793. http://dx.doi.org/10.1210/endo-124-4-1788

Butler, E. A., Wilhelm, F. H., & Gross, J. J. (2006). Respiratory sinus arrhythmia, emotion, and emotion regulation during social interaction. *Psychophysiology, 43,* 612–622. http://dx.doi.org/10.1111/j.1469-8986.2006.00467.x

Cialdini, R. B., Brown, S. L., Lewis, B. P., Luce, C., & Neuberg, S. L. (1997). Reinterpreting the empathy–altruism relationship: When one into one equals oneness. *Journal of Personality and Social Psychology, 73,* 481–494. http://dx.doi.org/10.1037/0022-3514.73.3.481

Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology, 24,* 349–354. http://dx.doi.org/10.1037/h0047358

Cuthbert, B. N., Bradley, M. M., & Lang, P. J. (1996). Probing picture perception: Activation and emotion. *Psychophysiology, 33,* 103–111. http://dx.doi.org/10.1111/j.1469-8986.1996.tb02114.x

Cutlip, W. D., II, & Leary, M. R. (1993). Anatomic and physiological bases of social blushing: Speculations from neurology and psychology. *Behavioural Neurology, 6,* 181–185. http://dx.doi.org/10.1155/1993/347841

Darwin, C. (1872). *The expression of emotions in man and animals*. New York: Philosophical Library. http://dx.doi.org/10.1037/10001-000

Davidson, R. J. (2002). Toward a biology of positive affect and compassion. In R. J. Davidson & A. Harrington (Eds.), *Visions of compassion: Western scientists and Tibetan Buddhists examine human nature* (pp. 107–130). New York: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780195130430.003.0006

Dawson, M. E., Schell, A. M., & Filion, D. L. (2000). The electrodermal system. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (2nd ed., pp. 200–223). Cambridge, England: Cambridge University Press.

Demaree, H. A., Schmeichel, B. J., Robinson, J. L., Pu, J., Everhart, D. E., & Berntson, G. G. (2006). Up- and down-regulating facial disgust: Affective, vagal, sympathetic, and respiratory consequences. *Biological Psychology, 71,* 90–99.

Denver, J. W., Reed, S. F., & Porges, S. W. (2007). Methodological issues in the quantification of respiratory sinus arrhythmia. *Biological Psychology, 74,* 286–294. http://dx.doi.org/10.1016/j.biopsycho.2005.09.005

de Waal, F. B. M. (1996). *Good natured: The origins of right and wrong in humans and other animals*. Cambridge, MA: Harvard University Press.

Diamond, L. M., Fagundes, C. P., & Butterworth, M. R. (2012). Attachment style, vagal tone, and empathy during mother–adolescent interactions. *Journal of Research on Adolescence, 22,* 165–184. http://dx.doi.org/10.1111/j.1532-7795.2011.00762.x

Dickerson, S. S., Kemeny, M. E., Aziz, N., Kim, K. H., & Fahey, J. L. (2004). Immunological effects of induced shame and guilt. *Psychosomatic Medicine, 66,* 124–131. http://dx.doi.org/10.1097/01.PSY.0000097338.75454.29

Ditto, B., Eclache, M., & Goldman, N. (2006). Short-term autonomic and cardiovascular effects of mindfulness body scan meditation. *Annals of Behavioral Medicine, 32,* 227–234. http://dx.doi.org/10.1207/s15324796abm3203_9

Eisenberg, N., Fabes, R. A., Bustamante, D., Mathy, R. M., Miller, P. A., & Lindholm, E. (1988). Differentiation of vicariously induced emotional reactions in children. *Developmental Psychology, 24,* 237–246. http://dx.doi.org/10.1037/0012-1649.24.2.237

Eisenberg, N., Fabes, R. A., Karbon, M., Murphy, B. C., Wosinski, M., Polazzi, L., . . . Juhnke, C. (1996). The relations of children's dispositional prosocial behavior to emotionality, regulation, and social functioning. *Child Development, 67,* 974–992. http://dx.doi.org/10.2307/1131874

Eisenberg, N., Fabes, R. A., Miller, P. A., Fultz, J., Shell, R., Mathy, R. M., & Reno, R. R. (1989). Relation of sympathy and personal distress to prosocial behavior: A multimethod study. *Journal of Personality and Social Psychology, 57,* 55–66. http://dx.doi.org/10.1037/0022-3514.57.1.55

Eisenberg, N., Fabes, R. A., Murphy, B., Maszk, P., Smith, M., & Karbon, M. (1995). The role of emotionality and regulation in children's social functioning: A longitudinal study. *Child Development, 66,* 1360–1384. http://dx.doi.org/10.2307/1131652

Eisenberg, N., Fabes, R. A., Schaller, M., Miller, P., Carlo, G., Poulin, R., . . . Shell, R. (1991). Personality and socialization correlates of vicarious emotional responding. *Journal of Personality and Social Psychology, 61,* 459–470. http://dx.doi.org/10.1037/0022-3514.61.3.459

Eisenberg, N., Michalik, N., Spinrad, T. L., Hofer, C., Kupfer, A., Valiente, C., . . . Reiser, M. (2007). The relations of effortful control and impulsivity to children's sympathy: A longitudinal study. *Cognitive Development, 22,* 544–567.

Eisenberg, N., & Miller, P. A. (1987). The relation of empathy to prosocial and related behaviors. *Psychological Bulletin, 101,* 91–119. http://dx.doi.org/10.1037/0033-2909.101.1.91

Ekman, P. (1992). Are there basic emotions? *Psychological Review, 99,* 550–553. http://dx.doi.org/10.1037/0033-295X.99.3.550

Fabes, R. A., Eisenberg, N., & Eisenbud, L. (1993). Behavioral and physiological correlates of children's reactions to others in distress. *Developmental Psychology, 29,* 655–663. http://dx.doi.org/10.1037/0012-1649.29.4.655

Frazier, T. W., Strauss, M. E., & Steinhauer, S. R. (2004). Respiratory sinus arrhythmia as an index of emotional response in young adults. *Psychophysiology, 41,* 75–83. http://dx.doi.org/10.1046/j.1469-8986.2003.00131.x

Fredrickson, B. L., & Kahneman, D. (1993). Duration neglect in retrospective evaluations of affective episodes. *Journal of Personality and Social Psychology, 65,* 45–55. http://dx.doi.org/10.1037/0022-3514.65.1.45

Geisler, F. C. M., Kubiak, T., Siewert, K., & Weber, H. (2013). Cardiac vagal tone is associated with social engagement and self-regulation. *Biological Psychology, 93,* 279–286. http://dx.doi.org/10.1016/j.biopsycho.2013.02.013

Gilbert, P. (Ed.). (2013). *Compassion: Conceptualisations, research and use in psychotherapy*. Hove, England: Routledge.

Goetz, J. L., Keltner, D., & Simon-Thomas, E. (2010). Compassion: An evolutionary analysis and empirical review. *Psychological Bulletin, 136,* 351–374. http://dx.doi.org/10.1037/a0018807

Gray, M. A., Harrison, N. A., Wiens, S., & Critchley, H. D. (2007). Modulation of emotional appraisal by false physiological feedback during fMRI. *PLoS ONE, 2*(6), e546. http://dx.doi.org/10.1371/journal.pone.0000546

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology, 85,* 348–362.

Grossman, P., & Taylor, E. W. (2007). Toward understanding respiratory sinus arrhythmia: Relations to cardiac vagal tone, evolution and biobehavioral functions. *Biological Psychology, 74,* 263–285. http://dx.doi.org/10.1016/j.biopsycho.2005.11.014

Grossman, P., van Beek, J., & Wientjes, C. (1990). A comparison of three quantification methods for estimation of respiratory sinus arrhythmia. *Psychophysiology, 27,* 702–714. http://dx.doi.org/10.1111/j.1469-8986.1990.tb03198.x

Haidt, J. (2003). The moral emotions. In R. J. Davidson, K. R. Scherer, & H. Goldsmith (Eds.), *Handbook of affective sciences* (pp. 852–870). New York: Oxford University Press.

Hendriks, M. C., Rottenberg, J., & Vingerhoets, A. J. (2007). Can the distress-signal and arousal-reduction views of crying be reconciled? Evidence from the cardiovascular system. *Emotion, 7,* 458–463. http://dx.doi.org/10.1037/1528-3542.7.2.458

Hertenstein, M. J., Keltner, D., App, B., Bulleit, B. A., & Jaskolka, A. R. (2006). Touch communicates distinct emotions. *Emotion, 6,* 528–533. http://dx.doi.org/10.1037/1528-3542.6.3.528

Horberg, E. J., Oveis, C., & Keltner, D. (2011). Emotions as moral amplifiers: An appraisal tendency approach to the influences of distinct emotions upon moral judgments. *Emotion Review, 3,* 237–244. http://dx.doi.org/10.1177/1754073911402384

James, W. (1884). What is an emotion? *Mind, os-IX,* 188–205. http://dx.doi.org/10.1093/mind/os-IX.34.188

Keltner, D., Kogan, A., Piff, P. K., & Saturn, S. R. (2014). The sociocultural appraisals, values, and emotions (SAVE) framework of prosociality: Core processes from gene to meme. *Annual Review of Psychology, 65,* 425–460. http://dx.doi.org/10.1146/annurev-psych-010213-115054

Keltner, D., & Lerner, J. S. (2010). Emotion. In D. T. Gilbert, S. T. Fiske, & G. Lindzey (Eds.), *The handbook of social psychology* (pp. 317–352). New York: Wiley.

Keltner, D., Oatley, K., & Jenkins, J. M. (2013). *Understanding emotions*. New York: Wiley Global Education.

Kogan, A., Impett, E. A., Oveis, C., van der Löwe, I., & Keltner, D. (2014). *Compassion detection: Four cues used to infer compassion in others*. Manuscript submitted for publication.

Kogan, A., Oveis, C., Carr, E. W., Gruber, J., Mauss, I. B., Shallcross, A., . . . Keltner, D. (2014). Vagal activity is quadratically related to prosocial traits, prosocial emotions, and observer perceptions of prosociality. *Journal of Personality and Social Psychology*. Advance online publication. http://dx.doi.org/10.1037/a0037509

Kogan, A., Saslow, L. R., Impett, E. A., Oveis, C., Keltner, D., & Rodrigues Saturn, S. (2011). Thin-slicing study of the oxytocin receptor (OXTR) gene and the evaluation and expression of the prosocial disposition. *Proceedings of the National Academy of Sciences of the United States of America, 108*, 19189–19192. http://dx.doi.org/10.1073/pnas.1112658108

Kok, B. E., Coffey, K. A., Cohn, M. A., Catalino, L. I., Vacharkulksemsuk, T., Algoe, S. B., . . . Fredrickson, B. L. (2013). How positive emotions build physical health: Perceived positive social connections account for the upward spiral between positive emotions and vagal tone. *Psychological Science, 24,* 1123–1132. http://dx.doi.org/10.1177/0956797612470827

Kok, B. E., & Fredrickson, B. L. (2010). Upward spirals of the heart: Autonomic flexibility, as indexed by vagal tone, reciprocally and prospectively predicts positive emotions and social connectedness. *Biological Psychology, 85,* 432–436. http://dx.doi.org/10.1016/j.biopsycho.2010.09.005

Krygier, J. R., Heathers, J. A., Shahrestani, S., Abbott, M., Gross, J. J., & Kemp, A. H. (2013). Mindfulness meditation, well-being, and heart rate variability: A preliminary investigation into the impact of intensive Vipassana meditation. *International Journal of Psychophysiology, 89,* 305–313. http://dx.doi.org/10.1016/j.ijpsycho.2013.06.017

Levenson, R. W. (1992). Autonomic nervous system differences among emotions. *Psychological Science, 3,* 23–27. http://dx.doi.org/10.1111/j.1467-9280.1992.tb00251.x

Levenson, R. W. (2003). Autonomic specificity and emotion. In R. J. Davidson, K. R. Scherer, & H. H. Goldsmith (Eds.), *Handbook of affective sciences* (pp. 212–224). New York: Oxford University Press.

Levenson, R. W., & Gottman, J. M. (1983). Marital interaction: Physiological linkage and affective exchange. *Journal of Personality and Social Psychology, 45,* 587–597. http://dx.doi.org/10.1037/0022-3514.45.3.587

Levine, L. J., & Safer, M. A. (2002). Sources of bias in memory for emotions. *Current Directions in Psychological Science, 11,* 169–173. http://dx.doi.org/10.1111/1467-8721.00193

Ludwig, D. S., & Kabat-Zinn, J. (2008). Mindfulness in medicine. *JAMA, 300,* 1350–1352. http://dx.doi.org/10.1001/jama.300.11.1350

Marsh, P., Beauchaine, T. P., & Williams, B. (2008). Dissociation of sad facial expressions and autonomic nervous system responding in boys with disruptive behavior disorders. *Psychophysiology, 45,* 100–110.

Mathews, A., Richards, A., & Eysenck, M. (1989). Interpretation of homophones related to threat in anxiety states. *Journal of Abnormal Psychology, 98,* 31–34. http://dx.doi.org/10.1037/0021-843X.98.1.31

Mauss, I. B., Levenson, R. W., McCarter, L., Wilhelm, F. H., & Gross, J. J. (2005). The tie that binds? Coherence among emotion experience, behavior, and physiology. *Emotion, 5,* 175–190. http://dx.doi.org/10.1037/1528-3542.5.2.175

McClelland, G. H., & Judd, C. M. (1993). Statistical difficulties of detecting interactions and moderator effects. *Psychological Bulletin, 114,* 376–390. http://dx.doi.org/10.1037/0033-2909.114.2.376

Mikulincer, M., & Shaver, P. R. (2005). Attachment security, compassion, and altruism. *Current Directions in Psychological Science, 14,* 34–38. http://dx.doi.org/10.1111/j.0963-7214.2005.00330.x

Ming, X., Julu, P. O., Brimacombe, M., Connor, S., & Daniels, M. L. (2005). Reduced cardiac parasympathetic activity in children with autism. *Brain & Development, 27,* 509–516. http://dx.doi.org/10.1016/j.braindev.2005.01.003

Moons, W. G., Eisenberger, N. I., & Taylor, S. E. (2010). Anger and fear responses to stress have different biological profiles. *Brain, Behavior, and Immunity, 24,* 215–219. http://dx.doi.org/10.1016/j.bbi.2009.08.009

Muhtadie, L., Koslov, K., Akinola, M., & Mendes, W. B. (in press). Vagal flexibility: A physiological predictor of social sensitivity. *Journal of Personality and Social Psychology*.

Nussbaum, M. C. (2003). *Upheavals of thought: The intelligence of emotions.* New York: Cambridge University Press.

Oppenheimer, J. E., Measelle, J. R., Laurent, H. K., & Ablow, J. C. (2013). Mothers' vagal regulation during the still-face paradigm: Normative reactivity and impact of depression symptoms. *Infant Behavior and Development, 36,* 255–267.

Oveis, C., Cohen, A. B., Gruber, J., Shiota, M. N., Haidt, J., & Keltner, D. (2009). Resting respiratory sinus arrhythmia is associated with tonic positive emotionality. *Emotion, 9,* 265–270.

Oveis, C., Horberg, E. J., & Keltner, D. (2010). Compassion, pride, and social intuitions of self–other similarity. *Journal of Personality and Social Psychology, 98,* 618–630. http://dx.doi.org/10.1037/a0017628

Porges, S. W. (2001). The polyvagal theory: Phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology, 42,* 123–146. http://dx.doi.org/10.1016/S0167-8760(01)00162-3

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology, 74,* 116–143. http://dx.doi.org/10.1016/j.biopsycho.2006.06.009

Rainville, P., Bechara, A., Naqvi, N., & Damasio, A. R. (2006). Basic emotions are associated with distinct patterns of cardiorespiratory activity. *International Journal of Psychophysiology, 61,* 5–18. http://dx.doi.org/10.1016/j.ijpsycho.2005.10.024

Rash, J. A., & Prkachin, K. M. (2013). Cardiac vagal reactivity during relived sadness is predicted by affect intensity and emotional intelligence. *Biological Psychology, 92,* 106–113. http://dx.doi.org/10.1016/j.biopsycho.2012.11.009

Rockliff, H., Gilbert, P., McEwan, K., Lightman, S., & Glover, D. (2008). A pilot exploration of heart rate variability and salivary cortisol responses to compassion-focused imagery. *Clinical Neuropsychiatry, 5,* 132–139.

Rosas-Ballina, M., Olofsson, P. S., Ochani, M., Valdés-Ferrer, S. I., Levine, Y. A., Reardon, C., . . . Tracey, K. J. (2011, September 15). Acetylcholine-synthesizing T cells relay neural signals in a vagus nerve circuit. *Science, 334,* 98–101. http://dx.doi.org/10.1126/science.1209985

Rottenberg, J., Salomon, K., Gross, J. J., & Gotlib, I. H. (2005). Vagal withdrawal to a sad film predicts subsequent recovery from depression. *Psychophysiology, 42,* 277–281. http://dx.doi.org/10.1111/j.1469-8986.2005.00289.x

Rottenberg, J., Wilhelm, F. H., Gross, J. J., & Gotlib, I. H. (2003). Vagal rebound during resolution of tearful crying among depressed and nondepressed individuals. *Psychophysiology, 40,* 1–6. http://dx.doi.org/10.1111/1469-8986.00001

Shaver, P., Schwartz, J., Kirson, D., & O'Connor, C. (1987). Emotion knowledge: Further exploration of a prototype approach. *Journal of Personality and Social Psychology, 52,* 1061–1086. http://dx.doi.org/10.1037/0022-3514.52.6.1061

Shearn, D., Bergman, E., Hill, K., Abel, A., & Hinds, L. (1990). Facial coloration and temperature responses in blushing. *Psychophysiology, 27,* 687–693. http://dx.doi.org/10.1111/j.1469-8986.1990.tb03194.x

Simon-Thomas, E. R., Godzik, J., Castle, E., Antonenko, O., Ponz, A., Kogan, A., & Keltner, D. J. (2012). An fMRI study of caring *vs* self-focus during induced compassion and pride. *Social Cognitive and Affective Neuroscience, 7,* 635–648. http://dx.doi.org/10.1093/scan/nsr045

Simon-Thomas, E. R., Keltner, D. J., Sauter, D., Sinicropi-Yao, L., & Abramson, A. (2009). The voice conveys specific emotions: Evidence from vocal burst displays. *Emotion, 9,* 838–846. http://dx.doi.org/10.1037/a0017810

Steffen, P. R., & Masters, K. S. (2005). Does compassion mediate the intrinsic religion–health relationship? *Annals of Behavioral Medicine, 30,* 217–224. http://dx.doi.org/10.1207/s15324796abm3003_6

Stellar, J. E., & Keltner, D. (2014). Compassion. In M. Tugade, L. Shiota, & L. Kirby (Eds.), *Handbook of positive emotion* (pp. 329–341). New York: Guilford Press.

Stellar, J. E., Manzo, V. M., Kraus, M. W., & Keltner, D. (2012). Class and compassion: Socioeconomic factors predict responses to suffering. *Emotion, 12,* 449–459. http://dx.doi.org/10.1037/a0026508

Thompson, R. A., Lewis, M. D., & Calkins, S. D. (2008). Reassessing emotion regulation. *Child Development Perspectives, 2,* 124–131. http://dx.doi.org/10.1111/j.1750-8606.2008.00054.x

Thrash, T. M., & Elliot, A. J. (2003). Inspiration as a psychological construct. *Journal of Personality and Social Psychology, 84,* 871–889. http://dx.doi.org/10.1037/0022-3514.84.4.871

Tracy, J. L., & Robins, R. W. (2007). The psychological structure of pride: A tale of two facets. *Journal of Personality and Social Psychology, 92,* 506–525. http://dx.doi.org/10.1037/0022-3514.92.3.506

Trivers, R. L. (1971). The evolution of reciprocal altruism. *Quarterly Review of Biology, 46,* 35–57. http://dx.doi.org/10.1086/406755

Tsai, J. L., Levenson, R. W., & Carstensen, L. L. (2000). Autonomic, subjective, and expressive responses to emotional films in older and younger Chinese Americans and European Americans. *Psychology and Aging, 15,* 684–693. http://dx.doi.org/10.1037/0882-7974.15.4.684

Valdesolo, P., & Desteno, D. (2011). Synchrony and the social tuning of compassion. *Emotion, 11,* 262–266. http://dx.doi.org/10.1037/a0021302

van Kleef, G. A., Oveis, C., van der Löwe, I., LuoKogan, A., Goetz, J., & Keltner, D. (2008). Power, distress, and compassion: Turning a blind eye to the suffering of others. *Psychological Science, 19,* 1315–1322. http://dx.doi.org/10.1111/j.1467-9280.2008.02241.x

Zahn-Waxler, C., Friedman, S. L., & Cummings, E. M. (1983). Children's emotions and behaviors in response to infants' cries. *Child Development, 54,* 1522–1528.

Received March 15, 2014
Revision received August 5, 2014
Accepted November 7, 2014 ■