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Giving support to others reduces sympathetic nervous system-related responses to stress

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Abstract

Social support is a major contributor to the link between social ties and beneficial health outcomes. Research to date has focused on how receiving support from others might be good for us; however, we know less about the health effects of giving support to others. Based on prior work in animals showing that stimulating neural circuitry important for caregiving behavior can reduce sympathetic-related responses to stressors, it is possible that, in humans, giving to others can reduce stressor-evoked sympathetic nervous system responding, which has implications for health outcomes. To test the effect of giving support on the physiological stress response, participants either wrote a supportive note to a friend (support-giving condition) or wrote about their route to school/work (control condition) before undergoing a standard laboratory-based stress task. Physiological responses (heart rate, blood pressure, salivary alpha-amylase, salivary cortisol), and self-reported stress were collected throughout the protocol. In line with hypotheses, support giving (vs. control) reduced sympathetic-related responses (systolic blood pressure and alpha-amylase) to the stressor. No effects of support giving were found on self-reported psychological stress or cortisol levels. Results add to existing knowledge of the pathways by which support giving may lead to health benefits and highlight the contribution of giving to others in the broader social support-health link.

Descriptors: Trier Social Stress Test, Social support provision, Caregiving, Salivary alpha-amylase, Blood pressure

One of the most provocative and influential findings from health psychology is the well-established link between social relationships and health. Those with more social ties tend to fare better on a number of health outcomes (Diener, Suh, Lucas, & Smith, 1999; Holt-Lundstad, Smith, & Layton, 2010; Taylor, 2007; Uchino, 2006) and live longer than those with fewer social ties (House, Landis, & Umberson, 1988). As part of this link, it has been theorized that having social support—the perception or experience that one is loved and cared for by others and part of a social network of mutual assistance and obligations (Wills, 1991)—is a major contributor to health. Yet, existing research on the social support-health link has tended to focus on the effects of receiving support and care. Another possibility is that the act of giving support to others confers health benefits for the individual performing the giving.

Some findings suggest that giving support is an overlooked contributor to the relationships-health link (Poulin, Brown, Dillard, & Smith, 2013). Giving to close others is associated with lower mortality rates over a 5-year period, even after controlling for the amount of support received (Brown, Nesse, Vinokur, & Smith, 2003). In addition, giving to others is associated with fewer sick days (Vaananen, Buunk, Kivimaki, Pentti, & Vahtera, 2005) and reduced cardiovascular activity (systolic and diastolic blood pressure, heart rate; Piferi & Lawler, 2006; cf. Creaven & Hughes, 2012; Nealey, Smith, & Uchino, 2002). Relatedly, older adults who actively volunteer (vs. those who do not) display a number of positive health benefits (Musick, Herzog, & House, 1999), such as reduced incidence of hypertension and increased psychological well-being (Sneed & Cohen, 2013). More broadly, giving to others by acting prosocially (vs. selfishly) leads to greater happiness (Dunn, Aknin, & Norton, 2008).

Why might giving support be good for us, and what biological mechanisms might link giving with better health? A number of theoretical perspectives propose that human beings are hardwired to nurture and care for others, especially young infants and children (Batson, 2011; Bowlby, 1988; Feeney & Collins, 2001; Preston, 2013). This care may be supported by an evolved mammalian caregiving system that subsequently helps support the caring of other individuals (Brown & Brown, 2006, 2015; Brown, Brown, & Preston, 2012; Eisenberger, 2013; Preston, 2013). Thus, the mechanisms that underlie giving support to others may (a) motivate approach-related caring behavior (e.g., via reliance on reward-related mechanisms), and (b) inhibit

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withdrawal or stress-related responding to facilitate adaptive caregiving during times of stress.

In a direct test of the role of mammalian caregiving regions in giving support to others in need, two neural regions known to be critical for maternal caregiving in animals—the ventral striatum (VS) and septal area (SA)—show increased activity to giving support to a romantic partner (vs. not giving support, Inagaki & Eisenberger, 2012). Furthermore, one of these regions, the SA, was negatively correlated with amygdala activity when participants gave support. The amygdala is a region well known for its association with threat detection and salience (Adolphs, Tranel, & Damasio, 1995; Anderson & Phelps, 2001; Whalen, 2007) and in animals, leads to increased cardiovascular responses (blood pressure, heart rate) when stimulated (Tellioglu, Aker, Oktay, & Onat, 1997). Similarly, amygdala activation to the Stroop color-word interference task has been linked to increased blood pressure (mean arterial pressure [MAP]) in humans (Gianaros et al., 2008). Conversely, stimulation of the SA on its own inhibits heart rate and blood pressure responses (Covian, Antunes-Rodrigues, & O'Flaherty, 1964; Malmo, 1961; Thomas, 1998) and has been proposed to show its most robust "quieting" effects on sympathetic nervous system (SNS) responding (Covian et al., 1964; Olds & Milner, 1954). Thus, the negative association between SA activity and amygdala activity during the provision of support suggests that support giving may reduce physiological stress responses for the person giving the support. From an evolutionary perspective, the stress-buffering effect of support giving may have been adaptive insofar as reducing one's own threat responses to seeing others under stress facilitates approach toward the target in need (Eisenberger, 2013; Inagaki & Eisenberger, 2012). Together, these findings suggest that support giving may confer health benefits by reducing physiological responses to stress, but not a lot of work has examined this experimentally.

To directly examine the effect of giving support to others on physiological stress responses, participants were randomly assigned to either give support to a friend in need or to complete a control condition. All participants then underwent a standardized laboratory-based stressor, the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). To examine physiological and psychological responses to stress, we assessed cardiovascular responses associated with sympathetic activity (heart rate, blood pressure), salivary alpha-amylase, an enzyme that indexes SNS activity (Nater & Rohleder, 2009; Rohleder, Nater, Wolf, Ehlert, & Kirschbaum, 2004), and self-reported anxiety and negative affect. We also explored the effect of support giving on salivary cortisol, as cortisol is a widely studied hormone associated with psychosocial stress. We hypothesized that, compared to a control condition where no support was given, support giving would lead to reduced physiological responses to the stressor.

Method

Participants

Healthy individuals were recruited via flyers. To be included in the study, participants needed to be in good health and over the age of 18. Exclusion criteria included major health or mental disorders (including hypertension, active coronary artery disease, diabetes, history of stroke, or fear of public speaking); use of medication such as beta-blockers, antidepressants, or other mood altering drugs; and pregnancy. Female participants on oral contraceptives were excluded, but two individuals (one from the support-giving condition and one from the control condition) reported oral contraceptive use during the experimental session. Results did not change with these individuals removed from the data, and so they were included in the final dataset. A total of 52 individuals participated in the study. One person was removed who, during the experimental session, reported poor health, cigarette and alcohol use, but did not report this during screening.

The final sample included 51 participants ($M_{age} = 21.02$, $SD = 2.67$, 37 females) with 39.2% Asian, 29.4% White, 11.8% Hispanic, 2% African American, and 17.7% reporting mixed ethnicity or other. Participants were paid $50 for completing the study. All procedures were approved by UCLA's Institutional Review Board.

Procedures Overview

Eligible participants were scheduled for an experimental laboratory session from 13:30–16:30 to control for the natural diurnal cortisol and alpha-amylase pattern (Dickerson & Kemeny, 2004; Rohleder et al., 2004; see Figure 1 for an overview of the procedures). Participants were asked to refrain from consuming any alcoholic beverages for 24 h before the session and to refrain from food, drink (other than water), or any oral activities that might cause the gums to bleed (e.g., flossing) 2 h prior to the session. Following an 85-min baseline period (see below for more details), participants were randomly assigned to complete either a 5-min support-giving manipulation ($n = 25$, 16 females) or a control condition ($n = 26$, 21 females), then complete the stressor (10 min), and finally complete 45 min of recovery time. There was no difference in the sex composition between the two conditions, $\chi^2(1, N = 51) = 1.82, p = .18$.

Baseline

Upon arrival to the lab, participants completed demographics and general self-reported health measures and then sat quietly for 40 min in order to acclimate to the laboratory environment. Two baseline physiological recordings and two saliva samples were then collected. Participants then sat quietly for another 45 min before continuing with the experimental procedures.

Support-Giving Manipulation

Approximately 85 min after arriving in the lab, participants completed the main experimental manipulation. Participants were instructed either to (a) handwrite a note addressed to a close friend who needs some support (support-giving condition), or (b) write about the route they take to school/work each day (control condition). They were given 5 min to complete the writing as they sat alone in a quiet room. A writing task was chosen for the manipulation because writing is a commonly used and successful manipulation for inducing specific psychological states (Galinsky & Ku, 2004; Galinsky & Moskowitz, 2000; Macrae, Bodenhausen, Milne, & Jetten, 1994). After completing their writing, all participants were asked to seal their note in an envelope so that someone from the research team could recode the content to remove any personal identifying information (such as the names of other people). This was done in order to protect the privacy of our participants and to encourage honest, supportive responses. Participants remained unaware of the exact details of the lab stressor (TSST) while completing their writing.

For participants assigned to the support-giving condition, the following instructions were given (both orally and written):

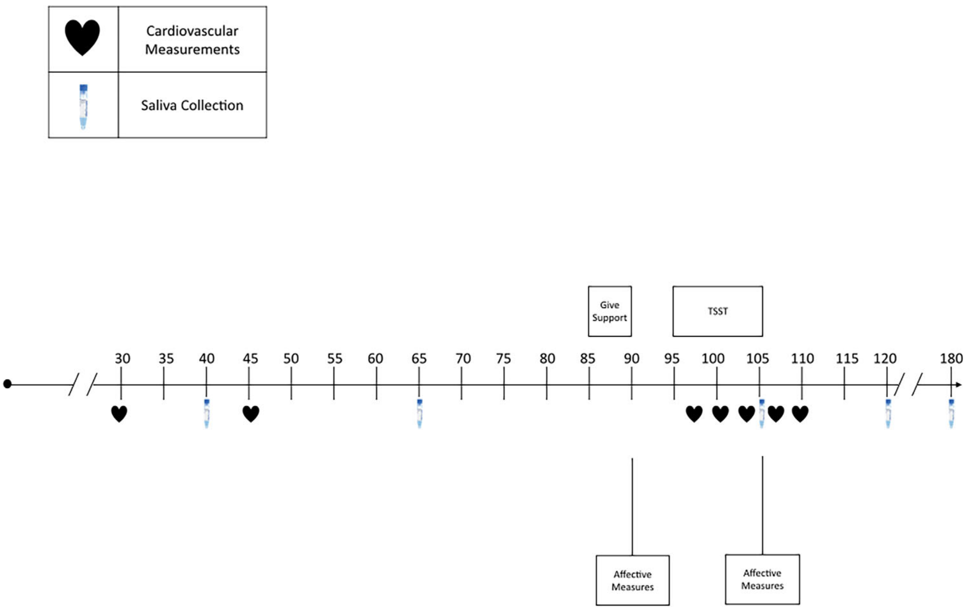

Figure 1. Overview of procedures. Following baseline measures, participants completed either the support-giving condition (wrote a supportive note to a friend) or a control condition (wrote about their route to school/work) and then underwent the Trier Social Stress Test (TSST). Heart rate, blood pressure, salivary alpha-amylase, salivary cortisol, and affective responses were assessed throughout the protocol.

For this study, we'd like you to pick a close friend who you know needs some support right now and write them a letter. Some examples might be a friend who just broke up with a romantic partner or someone worried about financial problems. You can write them advice or comforting words, whatever you think would be most helpful. Please write your response on the separate sheet of paper provided. You will have 5 minutes to write. When you are done, please place your letter in this envelope and seal it.

For the control condition, the following instructions were given:

For this study, we'd like you to write about the route you take to school/work each day. Please think about the exact route you take to school and describe the route you take—including step-by-step details of what directions you take, the scenery you pass on your way, etc. An example might be that you got on the #2 Santa Monica Blue Bus and rode 5 stops until you arrived at school and then got off in Westwood and walked down Westwood Blvd. and so on. Please write your response on the separate sheet of paper provided. You will have 5 minutes to write. When you are done, please place your letter in this envelope and seal it.

A representative example of a letter written by one participant in the support giving condition reads:

I know you have been going through a tough time these past few months and I just wanted to let you know that you are not alone. I am always here to listen if you ever need someone to talk to. You are not the only one who has been in this situation where you have to deal with financial problems as well as being stuck in the middle of your parents' divorce. I had to go through the same thing and it does get better.

An independent sample of raters ($n = 24$, 18 females) rated the supportiveness of the letters from the giving-support condition on a 7-point Likert scale (anchored by *not at all* and *very much so*) on the following items: (1) "Overall, how supportive do they seem?" (2) "To what extent do they express their concern for the difficulties the other is facing?" (3) "To what extent do they express encouragement (e.g., you can do it)?" (4) "To what extent do they validate the difficulty of the other's situation or express that they understand?" and (5) "How seriously do they take the other person's problem?" A composite of the five items ($\alpha = .95$) showed that the letters were generally supportive ($M = 4.92$, $SD = 1.07$). In addition, to assess whether those in the support-giving condition might be providing themselves with support rather than giving support to others, raters were asked how much the participant focused on his/her own perspective. Ratings on this item were significantly lower ($M = 3.92$, $SD = .90$) than the ratings for how supportive the letters were, $t(25) = 2.85$, $p = .009$, suggesting that the participants in the support-giving condition were indeed giving support to others. We wish to emphasize that the support manipulation in this study came before the introduction of the lab stressor, and thus participants were unaware that they were about to go through a stressful experience.

Laboratory-Based Stressor

After completing their writing, participants received instructions for the TSST, our laboratory-based stressor. Based on the standard protocol (Kirchbaum et al., 1993), participants were given 5 min to prepare a 5-min speech, to be delivered in front of a panel of evaluative judges, about why they would make a good candidate for an administrative assistant position. Immediately after the speech, participants completed a 5-min mental arithmetic task in which they were asked to count backwards by 13s from 2,083. To increase the stressfulness of this part of the protocol, participants were prodded to calculate faster and more accurately by the two trained confederates (always including at least one male) who acted as evaluators. In addition, participants were told that their speech and math performance would be videotaped and later coded for presentation style and clarity. Both confederates maintained neutral facial expressions throughout the TSST and did not give any reassuring gestures such as nods or smiles to support the participant through the task. Following the TSST, participants entered the recovery phase of the experiment where they sat quietly completing questionnaires for the remainder of the protocol.

Measures

Affective measures. Feelings of anxiety and negative affect to the experimental protocol were assessed at three separate time points: (1) before receiving instructions for the TSST (baseline), (2) during the TSST (stressor), and (3) after the TSST (recovery). For ratings reflecting the time period when they were going through the TSST (stressor ratings), participants were asked to retrospectively "indicate to what extent you felt this way while you were going through the stress tasks." Feelings of anxiety were measured using the state version of the Spielberger State-Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), and negative affect was measured with the negative items from the Positive and Negative Affect Schedule (Watson, Clark, & Tellegen, 1988).

In addition to feelings of anxiety and negative affect, five separate items assessed the stressfulness of completing the TSST (assessed at only one time point—feelings during the TSST). Thus, participants responded to "How evaluated did you feel during the tasks?," "How effortful/challenging/threatening was it to complete the tasks?" and "How difficult did you find the tasks?" A reliability analysis of the five items showed that responses had high convergence ($\alpha = .73$), and so responses were combined into a measure of "perceived stressfulness" during the TSST. Finally, participants were asked how well overall they thought they did during the tasks to get a more global measure of how well participants thought they performed during the TSST. This item showed low convergence with the other five items and so was evaluated on its own.

Physiological Measures

Cardiovascular measures. To measure the cardiovascular response to the TSST, heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were assessed with an automated monitor (Dinamap PRO Monitor) placed around the upper portion of the nondominant arm at baseline (once 30 min and once 45 min after arriving at the lab), during the stressor (once every 3 min over the 10-min TSST task), and during the recovery phase (immediately after the end of the TSST and 3 min later). Values within each measurement period (baseline, stressor, and recovery) were averaged to reflect the cardiovascular response during each time period. Stressor readings for one participant from the control condition were not collected due to experimenter error. The results for the cardiovascular measurements are therefore based on a sample of 25 individuals from the control condition and 25 individuals from the support-giving condition.

Overview of Saliva Sampling

Five saliva samples were collected throughout the experimental protocol to assess alpha-amylase and cortisol, two commonly studied salivary biomarkers associated with stress (Dickerson & Kemeny, 2004; Nater & Rohleder, 2009). Saliva was collected with salivettes (Salivettes, Sarstedt Inc., Newton, NC) twice at baseline (40 min and 65 min after entering the lab), twice after the stressor (1 min following the end of the TSST for salivary alpha-amylase [sAA] and 15 min following the end of the TSST for cortisol), and once during recovery (40 min after the end of the TSST).

Samples were stored in a −20°C freezer until they were analyzed. After data collection was complete, samples were analyzed with a time-resolved fluorescence immunoassay (Dressendorfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992) at the biological psychology laboratory directed by Dr. Clemens Kirschbaum at the Technical University of Dresden in Dresden, Germany. Raw sAA values were used because they did not demonstrate significant skew; however, cortisol values were log-transformed because they demonstrated positive skew.

Salivary Alpha-Amylase. sAA is a salivary biomarker that reflects SNS activity and has been shown to increase to psychosocial stress (Nater & Rohleder, 2009; Rohleder et al., 2004). Analyses focused on the effect of the experimental condition on the entire physiological time course; however, based on the hypothesis that support giving would be stress reducing, we were primarily interested in changes from baseline to the stressor.

There was an increase in sAA responding from the 40-min baseline ($M = 60.61$ U/ml, $SD = 49.96$) to the 65-min baseline sample ($M = 80.84$ U/ml, $SD = 50.80$; $F(1,45) = 3.69$, $p = .06$), suggesting that the second baseline may have served as a prestress, rather than a baseline assessment, and so the first baseline measurement (40 min into the protocol) was used as the baseline measure. To capture stressor-evoked sAA activity, analyses focused on the first stressor time point (1 min after the completion of the TSST) as sAA is known to respond almost immediately to a stressor (Nater & Rohleder, 2009; Rohleder et al., 2004).

Salivary Cortisol. Cortisol, a commonly studied hormone associated with stress that reflects hypothalamic-pituitary-adrenocortical (HPA) axis responding (Kirschbaum & Hellhammer, 1994), was concurrently assessed with sAA.

There were no differences between the 40- and 65-min baseline cortisol samples ($p = .73$), and so we used an average of the first and second measurements to serve as the baseline. Cortisol displays a well-characterized delay in responding from the onset of a stressful experience (approximately 21–40 min from stressor onset; Dickerson & Kemeny, 2004). Therefore, analyses focused on the second stressor assessment (15 min after the completion of the TSST) in order to evaluate cortisol reactivity to the stressor.

Data Analysis

Baseline measures. Differences in self-reported demographic and health variables (age, body mass index [BMI], subjective health, coffee in the past 7 days, alcoholic beverages in the past 7 days, cigarette use, exercise on the day of the experimental session, trouble sleeping, or any upcoming major exams) between those who gave support and those who completed the control condition were assessed with *t* tests in SPSS.

Psychological measures. Self-reported changes in affective responses to the TSST (negative affect and anxiety) were analyzed with 2 (Condition: support giving vs. control) × 3 (Time: baseline vs. stressor vs. recovery) repeated measures analyses of variance (ANOVAs). Perceived stress and how participants felt they performed overall during the TSST, which were taken at a single time

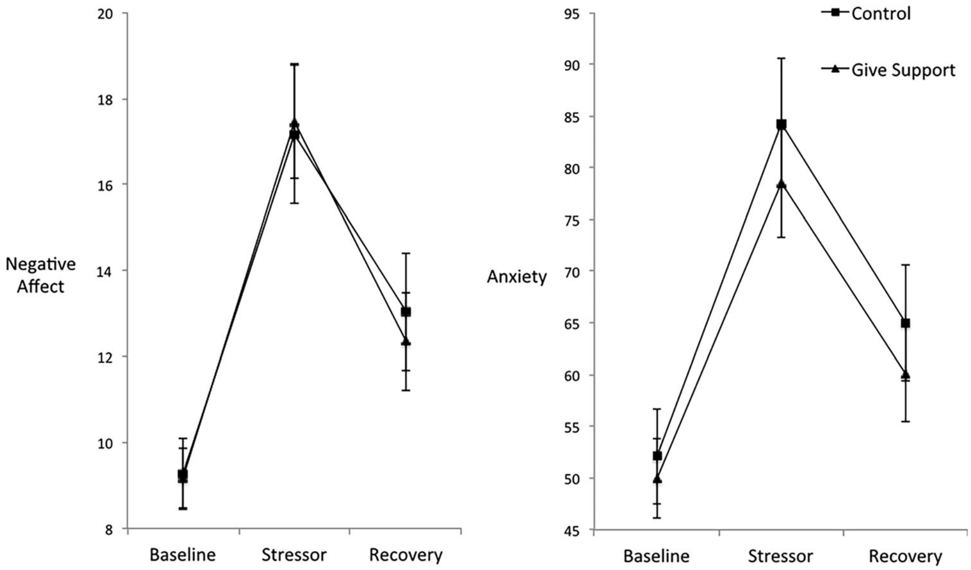

Figure 2. Self-reported negative affect and anxiety over time. Although self-reports increased from baseline to the stressor and then decreased during the recovery period, there were no differences between those who gave support and those who completed the control condition. Error bars reflect standard errors.

point, were analyzed using ANOVA with condition as the between-subjects factor.

Physiological measures. As a conservative control, any self-reported health variables that showed group differences at $p \leq .10$ were added as covariates when analyzing the physiological measurements. In this study, coffee intake over the past 7 days, $F(1,49) = 2.97$, $p = .09$, alcoholic beverages over the past 7 days, $\chi^2(1, N = 51) = 3.34$, $p = .07$, and exercise on the day of the experimental protocol, $\chi^2(1, N = 51) = 5.89$, $p = .02$, were reported more for those in the support-giving condition than those in the control condition. No other demographic or self-reported health measures showed any difference between conditions (age, BMI, subjective health, cigarette use, trouble sleeping, or any upcoming major exams, *ps* > .23). In addition, because previous studies have shown sex differences in physiological responses to stress (Kirschbaum, Wust, & Hellhammer, 1992; Kudielka & Kirschbaum, 2005; Smith, Loving, Crockett, & Campbell, 2009; Stoney, Davis, & Matthews, 1987) and because there were baseline differences in SBP responses between the males (M SBP = 114.50, $SD = 10.12$) and females (M SBP = 103.56, $SD = 9.74$; $F(1,49) = 12.80$, $p = .001$), sex was included as an additional variable in all analyses examining physiological responses to stress. However, there are no sex-specific hypotheses in the current study nor is the study powered enough to thoroughly evaluate sex differences. Therefore, caution should be made when evaluating sex effects.

Thus, 2 (Condition: support giving vs. control) × 3 (Time: baseline vs. stressor vs. recovery) × 2 (Sex: female vs. male) repeated measures ANOVAs were run to determine the effect of the experimental manipulation on the stress response. Given the current literature on the effects of maternal caregiving neural activity on responses to stressor-evoked physiological activity in animals (e.g., Covian et al., 1964; Olds & Milner, 1954), we were particularly interested in the effect of giving support on stressor reactivity (baseline vs. stressor) and, therefore, did not make specific hypotheses about the recovery period.

Results

Baseline Comparisons

There were no between-group (support giving vs. control condition) differences in baseline negative affect or anxiety, cardiovascular measures (HR, SBP, DBP), sAA, or cortisol (*ps* > .28).

Affective Responses to the Stressor

We first examined the effect of support giving on changes in self-reported responses to the TSST by examining the Time (baseline vs. stressor vs. recovery) × Condition (support giving vs. control) interaction. Consistent with prior studies using the TSST, there was a main effect of time for both anxiety, $F(2,98) = 55.14$, $p < .001$, and negative affect, $F(2,98) = 56.55$, $p < .001$ (see Figure 2). Post hoc analyses revealed that participants reported increased anxiety, $t(50) = 8.42$, $p < .001$, and negative affect, $t(50) = 8.75$, $p < .001$, from baseline to the stressor and then a reduction in anxiety, $t(50) = 8.33$, $p < .001$, and negative affect, $t(50) = 6.75$, $p < .001$, during the recovery phase (from the stressor to the recovery time point). However, there were no Condition × Time interactions, indicating that there were no differences in self-reported anxiety or negative affect between those who gave support and those who completed the control condition (*ps* > .54).

For the perceived stressfulness measure (which was measured at only one time point—in response to the stressor), there was no effect of support giving on how stressful participants found the TSST, $F(1,49) = 1.44$, $p > .24$. However, when looking at how well participants thought they did during the tasks (the speech and mental math portion of the TSST) overall, those in the support-giving condition reported doing marginally better ($M = 3.88$, $SD = 1.39$) than those in the control condition ($M = 3.19$, $SD = 1.36$, $F(1,49) = 3.19$, $p = .08$, $d = .50$). Thus, in sum, there was no effect of support giving on self-reported anxiety or negative affect, but, overall, participants in the support-giving condition felt they performed better during the TSST.

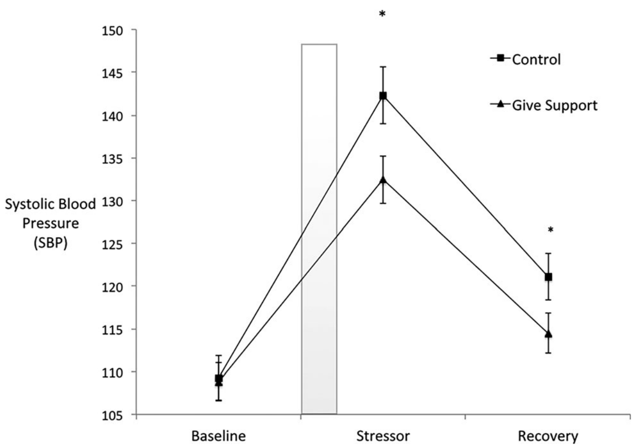

Figure 3. Systolic blood pressure (SBP) responding during the baseline, stressor, and recovery periods. While all participants showed the characteristic increases in SBP to the TSST, those in the control condition showed a larger SBP response during the stressor than those in the support-giving condition, suggesting that giving support to others buffers stressor-related SBP responding. The gray bar reflects the writing manipulation during which time participants either gave support or completed the control condition. Error bars reflect standard errors. $^*p < .05$

Physiological Outcomes

Cardiovascular responses. The interaction among condition (support giving vs. control), time (baseline vs. stressor vs. recovery), and sex (male vs. female) was assessed for each cardiovascular measurement (HR, SBP, DBP) separately. Results for HR, SBP, and DBP follow.

Heart rate. As expected, there was a significant effect of time for HR, $F(2,86) = 41.62$, $p < .001$, such that HR increased from baseline ($M = 65.33$, $SD = 8.67$) to the stressor ($M = 81.98$, $SD = 13.44$, $t(50) = 10.78$, $p < .001$) and then decreased during the recovery period ($M = 65.77$, $SD = 10.08$, $t(50) = 12.46$, $p < .001$). There was no main effect of sex for HR, $F(1,43) = .61$, $p = .44$, nor were there any interactions with sex ($ps > .51$). In addition, there was no interaction between condition and time, $F(2,86) = .04$, $p = .96$, indicating that the support-giving manipulation did not affect HR responses to the TSST.

Systolic blood pressure. As with heart rate, there was a main effect of time for SBP responding, $F(2,86) = 73.32$, $p < .001$ (see Figure 3) with SBP increasing from baseline to the stressor, $t(50) = 18.36$, $p < .001$, and decreasing during the recovery period, $t(50) = 11.90$, $p < .001$. There was also a significant main effect of sex for SBP, $F(1,43) = 17.88$, $p < .001$, such that males showed a greater overall SBP response than females. However, no interactions with sex were found ($ps > .50$).

Importantly, there was a significant interaction between condition and time (baseline vs. stressor vs. recovery) for SBP, $F(2,86) = 3.37$, $p = .04$. When breaking down the interaction to assess the direction of the effects, as expected, there were no differences at baseline between those who gave support and those who completed the control task, $F(1,43) = .02$, $p = .91$; however, in line with the hypothesis that support giving may be stress buffering, those who gave support showed a smaller SBP response to the stressor than those who went through the control condition, $F(1,43) = 4.85$, $p = .03$, $d = .64$ (Figure 3). There were no differences between condition for the stressor recovery period, $F(1,43) = .60$, $p = .44$.

Thus, even though participants did not report any differences in how anxious or stressed they felt in response to the stressor, participants in the support-giving condition (vs. control condition) showed a smaller increase in systolic blood pressure responding to the stressor.

Diastolic blood pressure. DBP responding showed the expected main effect of time, $F(2,86) = 64.30$, $p < .001$, with an increase in responding from baseline ($M = 64.50$, $SD = 7.39$) to the stressor ($M = 84.09$, $SD = 9.73$, $t(50) = 17.72$, $p < .001$) and a decrease from the stressor to recovery ($M = 70.22$, $SD = 7.74$, $t(50) = 9.99$, $p < .001$). Males also displayed a greater overall DBP response than females, $F(1,43) = 6.32$, $p = .02$. However, there were no other interactions with sex ($ps > .59$), and there was no Time × Condition interaction for DBP, $F(2,86) = .51$, $p = .60$.

Salivary alpha-amylase. To assess the effect of support giving on sAA activity, analyses focused on the first baseline time point, the time point immediately following the TSST, and recovery. sAA responses showed a main effect of time, $F(2,86) = 10.08$, $p < .001$ (see Figure 4), increasing from baseline to the stressor, $t(50) = 7.22$, $p < .001$, and decreasing during recovery, $t(50) = 6.05$, $p < .001$. There was no main effect of or interactions with sex ($ps > .23$). However, there was a marginal Condition × Time interaction, $F(2,86) = 2.455$, $p = .09$. Breaking down this interaction revealed a marginal interaction between condition and time for the stressor reactivity period (baseline vs. stressor), $F(1,43) = 3.31$, $p = .08$, but not for the stressor recovery period, $F(1,43) = 2.19$, $p = .15$, suggesting that support giving may be affecting sAA responses to the stressor specifically. Further analysis of the interaction revealed that those in the control condition showed a significant increase from baseline to the TSST, $F(1,21) = 8.98$, $p = .007$, whereas those who gave support showed less of an increase, $F(1,20) = 3.19$, $p = .09$ (Figure 4). That is, those who gave support (vs. those who did not) showed reduced SNS activity in response to the stressor.

Salivary cortisol. We also explored the effect of support giving on changes in cortisol in response to the stress task. To do this, we focused on cortisol responding at baseline, 15 min poststressor,

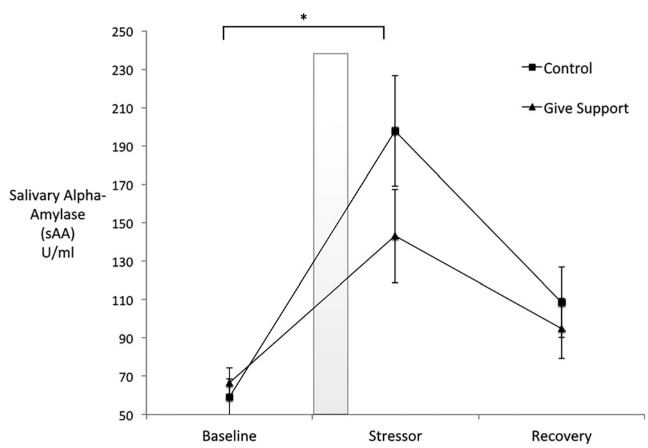

Figure 4. Salivary alpha-amylase (sAA) from baseline to stressor to recovery. There was a marginal interaction between the experimental conditions and the change in sAA responding from the baseline to the stressor such that those in the control condition showed a significant increase from baseline to the stressor while those who gave support did not. The gray bar reflects the writing manipulation, and the error bars reflect standard errors. $^*p = .09$

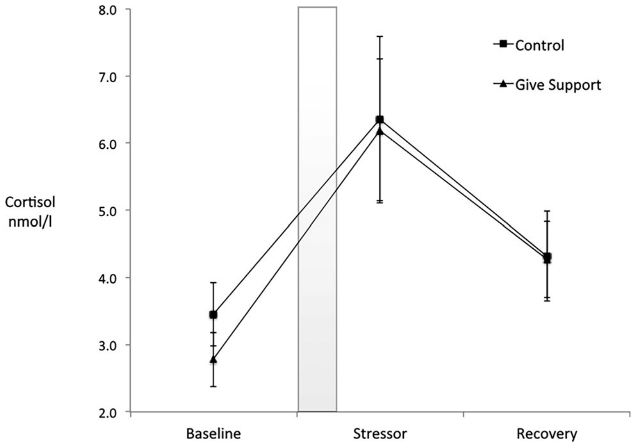

Figure 5. Salivary cortisol responses to the TSST. All participants showed an increase in cortisol to the stressor, but no effect of support giving was found. Graphed values are raw values for display purposes only; however, analyses were performed on log-transformed values. Error bars are standard errors.

which is the time that has been shown to capture the peak stress-induced cortisol response (Dickerson & Kemeny, 2004), and then recovery. Consistent with prior work showing that the TSST elicits a cortisol response, there was a main effect of time, $F(2,86) = 4.47$, $p = .01$, with the expected increase in cortisol from baseline to the stressor, $t(50) = 3.47$, $p = .001$, and a decrease during recovery, $t(50) = 2.08$, $p = .04$. However, there was no main effect of or interactions with sex (ps $> .13$), and there was no Condition × Time interaction, $F(2,86) = .81$, $p = .45$ (Figure 5).

Discussion

Although the contribution of social support to psychological, physical, and relationship well-being is substantiated by a large empirical literature, the underlying assumption has been that the benefits of social support come mainly from the support one receives from others. Another possibility, which has been comparatively overlooked, is that some of the benefits of social support may come from the support that one gives to others. A number of correlational studies suggest that support giving leads to better health outcomes (Brown et al., 2003; Poulin et al., 2013; Sneed & Cohen, 2013; Vaananen et al., 2005), but it remains unclear whether these health benefits are potentially driven by other factors such as the fact that individuals who are healthier may be more capable of giving to others, the trait disposition of those who tend to give to others, or other factors. In the current study, we avoid these potential confounds by showing that support giving (vs. a control task) reduced SBP and sAA responding to a stressor, suggesting that the act of giving in and of itself may contribute to beneficial health outcomes on its own.

Giving to others (vs. completing a control task) reduced stressor-evoked SNS-related responding (SBP, sAA), but not cortisol, the end product of the HPA axis and commonly studied part of the acute stress response. Although SNS and HPA measures have not been measured together in an experimental test of support giving before, the pattern of reduced SNS activity is consistent with previous work showing that those who report giving support more also show lower cardiovascular responding over a 24-h period (Piferi & Lawler, 2006). In addition, this pattern is in line with the implications from our previous neuroimaging work showing a negative correlation between SA and amygdala activity, two regions associated with downstream sympathetic responding, during support giving (vs. control; Inagaki & Eisenberger, 2012). In regard to long-term implications for health, SNS responding has direct and strong implications for health outcomes such as coronary heart disease, stroke, and renal disease (Flack et al., 1995; Stamler, Stamler, & Neaton, 1993). Furthermore, increased SNS activity leads to increased inflammatory responding, a major underlying contributor to many prevalent mental and physical diseases (Eisenberger & Cole, 2012). Thus, any dampening of SNS activity, in this case via support-giving behavior, may also dampen inflammatory responding. It is less clear, however, what the direct link is between acute stressor-related cortisol responding and negative health outcomes (Miller, Chen, & Zhou, 2007). Therefore, to the extent that support giving has its most robust stress-buffering effects on sympathetic responding, this may be one route by which giving to others leads to long-term health benefits. However, more work will be needed to replicate and extend the current findings as the hypothesized effect of giving support on stressor-evoked SNS activity was only marginally significant for one of our measures (sAA). Furthermore, future studies should include more time points to establish reliable baseline and recovery periods when examining the cardiovascular stress response.

Though not an explicit goal of the current study, it is possible that the current support-giving manipulation, where participants wrote a supportive note to someone in need, may have simply elicited mental representations of others who could provide social support (such as the manipulation used in Smith, Ruiz, & Uchino, 2004, on the effects of receiving support on the stress response). This seems unlikely given that the content of the support letters suggests that participants were really focused on the problem that their friend was going through and on helping them feel better instead of focusing more generally on the supportive qualities of this other person. However, future work on the effects of giving support on the acute stress response will benefit from including an additional condition where participants write or think about supportive others, which may help disentangle effects of support giving from effects of thinking of others more broadly.

This study also highlighted a dissociation between the psychological experience of going through the stressor and the physiological response. Those who gave support reported feeling as anxious and stressed during the stressor as those who completed the control condition even though the support-givers had a reduced physiological stress response. This dissociation is consistent with a number of other findings in social and health psychology (e.g., Egloff et al., 2002; Kirschbaum, Klauer, Filipp, & Hellhammer, 1995) that demonstrate that self-reported experience in response to a stressor does not always map onto physiological responses to a stressor. Indeed, a neuroimaging investigation demonstrated that self-reported anxiety and physiological responding to a stress task were supported by different underlying neural systems (Wager et al., 2009), suggesting that subjective stress and physiological stress may rely on dissociable neural pathways. Although there were no effects of support giving on self-reported stress in this study, it will be important to continue to assess subjective experience and its relation to physiological responses when giving support to others in order to understand the entire psychological experience. For instance, perceptions of feeling needed and useful that come from giving to others in older adults is associated with better health and less mortality over a 10-year follow-up (Gruenewald, Liao, & Seeman, 2012). Future work that assesses how giving to others affects an individual's subjective psychological experience outside of the stressful context of the laboratory may help delineate the boundary conditions of when giving is most beneficial for health.

Finally, it is important to note that the notion that giving support to others may lead to beneficial health outcomes appears to contradict the established literature on the link between caring for a loved one with a terminal illness and negative health outcomes (e.g., Schulz & Beach, 1999). However, giving support and care to others in an acute setting, as manipulated in the current study, is a fundamentally different experience from the chronic caregiving of another person. For instance, chronic caregiving involves giving support to another person, but also involves watching the deterioration and/or suffering of that loved one. Studies linking chronic caregiving to poor health outcomes have typically failed to control for the emotional distress of losing a loved one, and because they cannot randomize participants, in an experimental way, to chronic caregiving versus control conditions, it remains unclear whether the support-giving part of chronic caregiving is the "active ingredient" in the association between caregiving and poor health or if there are other factors that contribute to negative health outcomes. In fact, one study suggests that chronic caregiving is associated with beneficial, rather than detrimental, health outcomes such as a reduced risk of mortality (Brown et al., 2009). In addition, research has shown that caregivers of parents without severe care needs do not show increased depressive symptoms, but that noncaregivers of parents with severe care needs do report greater depressive symptoms (Amirkhanyan & Wolf, 2003). Together, these studies point to the possibility that the support giving itself may not be the cause of the negative health effects. However, further research is needed in order to determine when providing care and support to others affects health for the better or worse.

In summary, the current study experimentally manipulated support giving prior to a stressful experience. Findings show that giving to others (vs. a control condition) can reduce the physiological stress response and, in particular, sympathetic-related responding (SBP, sAA). Together with our previous findings on the neural correlates of support giving and other work on mechanisms by which giving to others is beneficial for well-being, we begin to uncover a pathway by which support giving may lead to better health outcomes.

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