Neural Correlates of Giving Social Support: Differences Between Giving Targeted Versus Untargeted Support

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ABSTRACT

Objective: Giving support contributes to the link between social ties and health; however, the neural mechanisms are not known. Giving support in humans may rely on neural regions implicated in parental care in animals. The current studies, therefore, assess the contribution of parental care–related neural regions to giving support in humans and, as a further theoretical test, examine whether the benefits of giving *targeted* support to single, identifiable individuals in need extend to giving *untargeted* support to larger societal causes.

Methods: For study 1 (n = 45, M (SD) age = 21.98 (3.29), 69% females), participants completed a giving support task, followed by an emotional faces task in the functional magnetic resonance imaging scanner. For study 2 (n = 382, M (SD) age = 43.03 (7.28), 52% females), participants self-reported on their giving support behavior and completed an emotional faces task in the functional magnetic resonance imaging scanner.

Results: In study 1, giving targeted (versus untargeted) support resulted in greater feelings of social connection and support effectiveness. Furthermore, greater septal area activity, a region centrally involved in parental care in animals, to giving targeted support was associated with less right amygdala activity to an emotional faces task ($r = -.297$, 95% confidence interval = −.547 to −.043). Study 2 replicated and extended this association to show that self-reports of giving targeted support were associated with less amygdala activity to a different emotional faces task, even when adjusting for other social factors ($r = -.105$, 95% confidence interval = −.200 to −.011). Giving untargeted support was not related to amygdala activity in either study.

Conclusions: Results highlight the unique benefits of giving targeted support and elucidate neural pathways by which giving support may lead to health.

Key words: altruism, helping, prosocial behavior, social support and health, support provision.

INTRODUCTION

Humans thrive off social connections and benefit when they act in the service of others' well-being. For example, giving support is associated with mental and physical health benefits including lower depressive symptoms (1), resting blood pressure (2), and greater longevity (3) (for reviews, see (4–6)). The link between giving support and health is likely driven by biological systems; therefore, it is important to understand the neurobiological effects of giving to others. However, the neural mechanisms of giving support have not been elucidated.

Recent theoretical perspectives take a cross-species approach to suggest that neural regions known to contribute to effective parental care in animals (7) may underlie the beneficial effects of giving support in humans (4–6). In particular, a system of neural regions implicated in parental behavior may extend to the human care of infants and others (e.g., friends, extended family). From this perspective, giving support is critical to ensuring the survival of offspring. Mechanisms may, therefore, be in place to reinforce giving support behavior. Specifically, neural mechanisms that (*a*) reinforce supportive behavior directed toward others (ventral striatum [VS], septal area [SA]) and (*b*) reduce withdrawal to facilitate care during times of need and to ensure continued supportive behavior (5,6). The aim of the present research was to assess the contribution of parental care–related neural regions as candidate mechanisms of giving support and, as a further test of theory, to examine whether the benefits of giving support to a single, identifiable individual in need (targeted support) extend to giving support to larger societal causes (untargeted support).

As evidence that giving support is reinforcing (i.e., increases and maintains approach behavior), work on parental care in animals shows that giving support activates neural regions that are also known for processing primary reinforcers (VS (8) and SA (9)). Thus, animal parental behavior, such as retrieval and nest building, increases activity in the VS and SA (10), whereas lesions to either of these regions disrupt parental care (11,12). Human studies similarly suggest that the VS and SA contribute to giving support. Giving (versus not giving) support to a romantic partner by holding his arm as he was threatened with electric shocks activated the VS and SA (13). Furthermore, giving support (versus not giving) increased feelings of social connection and feelings that

CI = confidence interval, **fMRI** = functional magnetic resonance imaging, **ROI** = region of interest, **SA** = septal area, **VS** = ventral striatum

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the support was effective. In another study, greater self-reported giving support (endorsing statements such as "when someone I lived with was sick I helped them") was associated with greater VS and SA to giving support to a close other in need (14).

Consistent with findings on the neural correlates of giving support to close others, neuroimaging studies on charitable giving, where participants have the opportunity to donate to charities, lead to increased activity in the VS (15) and SA (16). However, no studies have examined whether giving to a close other and giving to charity result in similar increases in the VS and SA in the same study.

Giving support to others is facilitated by reduction in withdrawal and defensive reactions to negative arousing stimuli (5,6). For instance, dampening reactions to witnessing another cry might help a giver approach and care for that individual. We have proposed that giving support may reduce withdrawal via an inhibitory connection between the SA and amygdala (17,18). Consistent with this hypothesis, greater SA as participants give (versus do not give) support to a romantic partner in need is associated with less amygdala activity to the same task (13). Outside of the brain, giving support (versus not giving) reduces blood pressure to a subsequent task, suggesting that the effects of giving extend beyond the moment of giving (19). To the extent that giving support activates the SA, giving support may also be associated with less amygdala activity to subsequent stimuli. However, this has not been tested.

Should giving support rely on less withdrawal, those who give the most support outside of the experimental setting may also show less amygdala activity to negative or arousing stimuli. In support of this individual differences view of giving, those who report more support-giving also show less amygdala activity to a social evaluative stressor (14). In addition, individual differences in observer coded parenting are associated with amygdala activity such that parents who give higher-quality care also show less amygdala activity to their own (versus stranger) infants (20). Those who report giving the most support may also show less amygdala to other arousing stimuli.

Giving Targeted Versus Untargeted Support

Implicit in the theory that giving support stems from parental care mechanisms (5,6) is that the origins of such behavior are given to an identifiable individual in need (i.e., the offspring). Should the benefits of giving support depend, in part, on mechanisms that originally evolved for this kind of *targeted support*, it is possible that the greatest benefits are accrued when the support given to others, whether that be offspring or another individual, is also targeted. An additional possibility suggested by the "warm glow" account of charitable giving (21) is that giving support in general, to societal causes or for the greater good, is beneficial. From this perspective, giving *untargeted* support (i.e., not targeted to a specific individual in need) may show the same neural patterns as targeted support.

To date, no studies have tested whether giving targeted and untargeted support result in similar neural patterns. However, previous findings outside of the social support literature suggest that responses to targeted needs are different from those to untargeted needs. From the empathy literature, giving to a single individual is greater than giving to a group or cause, a phenomenon known as the "identifiable victim effect" (22). For example, giving support to an identified (versus unidentified) target results in greater sympathy for (23) and monetary donation to the identified target (24). To date, no studies have examined the neural correlates of giving targeted and untargeted support in the same study.

Current Studies

The current studies were undertaken to assess whether the same neural patterns emerge when giving targeted support (i.e., given to a single, identifiable individual) and giving untargeted support (i.e., given to charities).

In study 1 (n = 45), participants completed a giving support task and then an emotional faces task in the functional magnetic resonance imaging (fMRI) scanner. Self-reported feelings of social connection, support effectiveness, and neural activity in the VS and SA were hypothesized to be greater when participants give targeted (versus untargeted) support. In addition, SA to giving targeted support was hypothesized to be negatively correlated with amygdala activity to emotional faces. SA to giving untargeted support was not hypothesized to relate to amygdala activity.

In study 2, associations between self-reports of giving targeted and untargeted support and amygdala activity to a different emotional faces task were evaluated in a separate, large sample of existing neuroimaging data (n = 384). Self-reports of giving targeted support were hypothesized to be negatively correlated with amygdala activity. Self-reports of giving untargeted support were not hypothesized to relate to amygdala activity.

Study 1

METHOD

Participants and Screening

Forty-eight healthy, right-handed individuals (run between January 2016 and April 2017) were recruited via flyers. We aimed to run a usable sample of 40 individuals. Participants were screened for current physical or mental illness, medication other than birth control, and contraindications for MRI (metal in the body, claustrophobia, pregnancy). Three participants were removed (2 with brain abnormalities, 1 for undisclosed medication use) leaving a sample of 45 individuals (M age = 21.98, age range = 18–34, 31 females). Procedures were run in accordance with the University of Pittsburgh's Institutional Review Board, and all participants provided informed consent before completing procedures.

Neuroimaging Measures

Giving Support Task

To examine parental care–related neural activity to giving targeted and untargeted support, participants completed a raffle task previously used to examine the neural correlates of giving targeted (13) and untargeted support (16) separately. In this task, participants had the opportunity to win raffle tickets for a close other (giving targeted support), for charities (giving untargeted support), and for themselves (self-reward). After the study was completed, raffle tickets were entered into a drawing for two US $200 prizes; the more tickets participants won during the task, the greater their chance of winning.

To heighten the believability that support was being given to others, participants were asked to think of someone who needed money and whether they could provide the contact information for their close other in the event that they won the raffle. Participants also read descriptions of 15 charities selected from the Combined Federal Campaign list (http://www.opm.gov/cfc). Causes ranged from the promotion of education and science to conservation and climate change. In the scanner, participants named the person they had chosen to play for and described their relationship to the participant. Participants chose to play for family members (55%), friends and significant others (34%), and roommates (11%).

The task consisted of four trial types beginning with a cue indicating who they were playing for, followed by an offer screen with a proposed distribution of raffle tickets (between −30 and +70 tickets). Participants could then accept or reject the entire offer (Figure 1). Trials were separated by jittered fixation (2–6 seconds, M = 3 seconds). During the key *giving* trials, participants could choose to give raffle tickets to the other party at a cost to themselves (e.g., YOU −10, OTHER +50). During *self-reward* trials, participants could win raffle tickets for themselves without cost to the other party (e.g., YOU +50, OTHER +0), and during *control* trials, no tickets could be won or lost (e.g., YOU +0, OTHER +0). *Costly reward* trials (e.g., YOU +50, OTHER −10) were included to encourage task engagement but were not analyzed. Ninety trials (40 giving, 20 self-reward, 20 control, and 10 costly reward) were included in each of two runs. The running total of tickets won was not shown. To assess neural activity to giving support, data analyses examined only the accepted offers. Three participants were excluded from imaging analyses (2 declined to give to either party, 1 declined to name a close other). Results from the giving support task are based on a sample of 42 participants.

Emotional Faces Task

To examine amygdala activity, participants viewed faces from the NimStim set of facial expressions (25) in a block design. Eight 30-second blocks of negative (angry, fearful) and nonnegative (happy, neutral) expressions (2 blocks of each expression) were separated by 12 seconds of fixation crosshair. Each block consisted of 20 facial expressions presented for 1.5 seconds each. To encourage task engagement, participants pressed a button each time a new face appeared on screen. Data from one participant was unusable because of a technical error leaving a sample of 44 participants for the emotional faces task.

fMRI Data Acquisition

Scanning occurred at the University of Pittsburgh's Neuroscience Imaging Center on a Siemens 3T MAGNETOM Allegra MRI Scanner. A Magnetization Prepared Rapid Gradient Echo scan (MP-RAGE; TR/TE = 1540/3.04 milliseconds, flip angle = 8°, 256 × 256 matrix, 192 sagittal slices, FOV = 256; 1-mm thick) was acquired before functional scans to aid in data registration. Participants then completed two runs of the giving support task (12 minutes, 24 seconds each), a single run of the emotional faces task (5 minutes, 56 seconds) and a resting state scan (not reported here; T_2*-weighted gradient-echo covering 36 axial slices, TR/TE = 2000/25 milliseconds; flip angle = 70°; 64 × 64 matrix; FOV = 200 mm; 3-mm thick). The emotional faces task always followed the giving support task to test the hypothesis that giving targeted support, but not untargeted support, might relate to amygdala activity to a separate task.

Self-Report Measures

Feelings of Social Connection

Feelings of social connection to giving targeted and untargeted support were collected after participants exited the scanner. If a participant chose to give support to the other party, they were asked the following (with 1 indicating “not at all” and 7 indicating “a great deal”): how connected do you feel to this person/the organizations?; how close do you feel to this person/the organizations?; and how disconnected do you feel from this person/the organizations? Responses were combined to assess feelings of social connection when giving targeted support to a close other (α = .70) and untargeted support to charities (α = .83).

Support Effectiveness

In addition to feelings of social connection, participants reported how effective they felt their support was. Participants responded to the following on a 1 (not at all) to 7 (a great deal) scale: how much did you enjoy helping this person/these organizations?; how effective was the help you provided?; and how much did you want to help this person/these organizations? The items were then combined to assess support effectiveness to giving targeted support (α = .80) and untargeted support (α = .90). Self-report data were missing from one participant because of a technical error, leaving a final sample of 44 participants for self-report measures. Feelings of social connection and support effectiveness were moderately correlated (*r*'s ≥ .50).

Statistical Analyses

Self-Report Analyses

To examine differences in feelings of social connection and support effectiveness to giving targeted versus untargeted support, paired samples *t* tests were run in SPSS v.24. For all analyses (study 2 included), 95% confidence

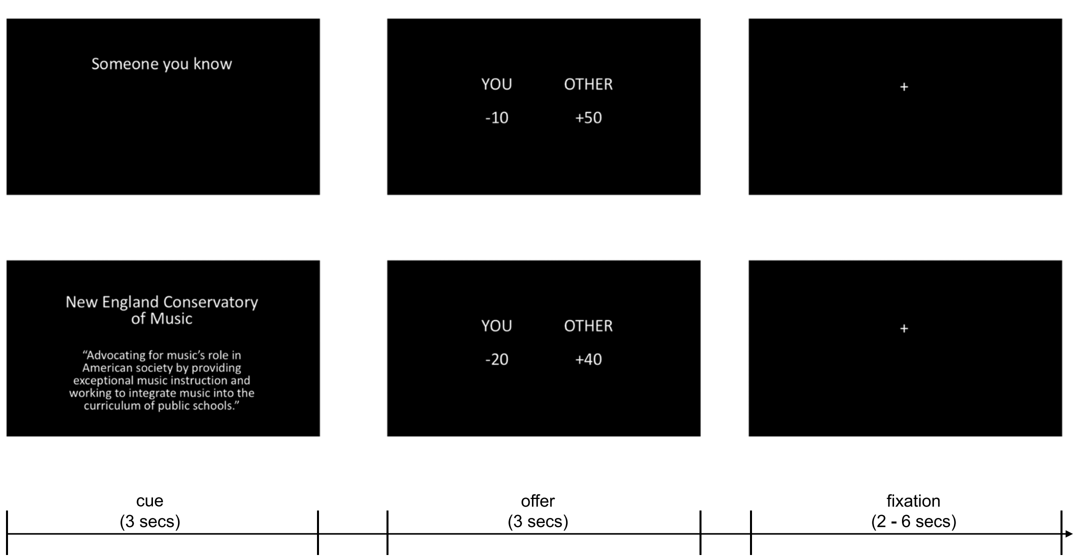

FIGURE 1. Representative giving trials from giving support task (study 1). Participants had the opportunity to give targeted support to a close other and give untargeted support to charities by accepting or rejecting a proposed distribution of raffle tickets (offer).

intervals (CI) were estimated using the bias corrected and accelerated percentile bootstrap method with 1000 random samples with replacement.

Neuroimaging Analyses

Imaging data were preprocessed in SPM8 (Wellcome Department of Imaging Neuroscience, London) using the DARTEL procedure. Images were realigned, normalized to the MP-RAGE and warped into Montreal Neurologic Institute space, and smoothed with an 8-mm Gaussian kernel, full width at half maximum. Main effects for each task were calculated using the general linear model. Linear contrasts were computed for each participant before group level analyses. For the giving support task, the primary aim was to examine differences between giving targeted and untargeted support from the giving versus control contrast. In keeping with previous reporting of the task, giving versus self-reward is also reported (1,14,16). For the emotional faces task, analyses were constrained to the negative versus nonnegative facial expressions because amygdala activity to negative faces has previously been associated with health (26) and social withdrawal tendencies (27), and we wished to remain consistent with task modeling for study 2 (see hereinafter).

Region-of-Interest Analyses

Based on the proposed theoretical model (5,6), activity in a-priori regions of interest (ROIs) of the VS, SA, and amygdala were examined. VS ROIs previously used to examine giving targeted support (13,14) were structurally defined by combining the caudate and putamen from the Automated Anatomical Labeling atlas (28) and constraining the regions at $-24 < x < -24$, $4 < y < 18$, and $-12 < z < 0$. A previously defined ROI of the SA (for details see (29)) that also relates to self-reported giving support (14) was used to examine SA activity. For the emotional faces task, amygdala ROIs were defined using the Automated Anatomical Labeling atlas. Although no laterality effects were hypothesized, left and right VS and amygdala are reported separately. ROI analyses were run in Marsbar (http://marsbar.sourceforge.net), thresholded at $p < .05$.

Associations between SA activity to giving targeted and untargeted support and amygdala activity to the emotional faces task were evaluated with correlational analyses in SPSS v.24.

RESULTS

Self-Report Results

Feelings of social connection and support effectiveness were hypothesized to be greater when participants gave targeted (versus untargeted) support. Consistent with this hypothesis and previous findings (15), feelings of social connection were greater when giving targeted than untargeted support ($t(43)= 8.495$, $p < .001$, 95% CI = 1.765 to 2.848) (Figure 2). Similarly, support effectiveness was greater when giving targeted than untargeted support ($t(43) = 7.88$, $p < .001$, 95% CI = 1.115 to 2.802). That is, participants reported feeling more socially connected and that their support was more effective when giving support to close others (versus charities).

Neuroimaging Results

Main Effects of Giving Support (Ignoring Target)

As a manipulation check that the giving support task would result in increased activity in the VS and SA, main effects from the giving trials were first evaluated ignoring the target of support. As expected, giving resulted in greater VS and SA activity than control (Table 1). Similarly, giving resulted in greater VS and SA activity than self-reward, consistent with previous work showing that giving to others can be more reinforcing than receiving for the self (1,14–16).

Main Effects of Giving Targeted Versus Untargeted Support

Next, differences in VS and SA activity were examined when participants gave targeted and untargeted support during giving versus control trials. No differences in VS activity were found between giving targeted and untargeted support (Table 1). Furthermore, opposite the hypothesized pattern, SA activity was lower to giving targeted than untargeted support. Upon further examination, the differences in SA activity seemed to be driven by participants who accepted less than 5 giving trials (3 participants for giving targeted support, 8 participants for giving untargeted support). When removing these participants, there were no differences in SA to giving targeted and untargeted support.

Similarly, there were no differences in VS and SA activity to giving targeted and untargeted support during giving versus self-reward trials. However, when removing participants who accepted less than five giving trials, SA activity was greater to giving targeted than untargeted support, providing some evidence for hypotheses.

Associations Between Neural Activity to the Giving Support Task and Emotional Faces Task

Based on the hypothesized inhibitory relationship between the SA and amygdala (5,6,17,18), the second aim was to examine whether

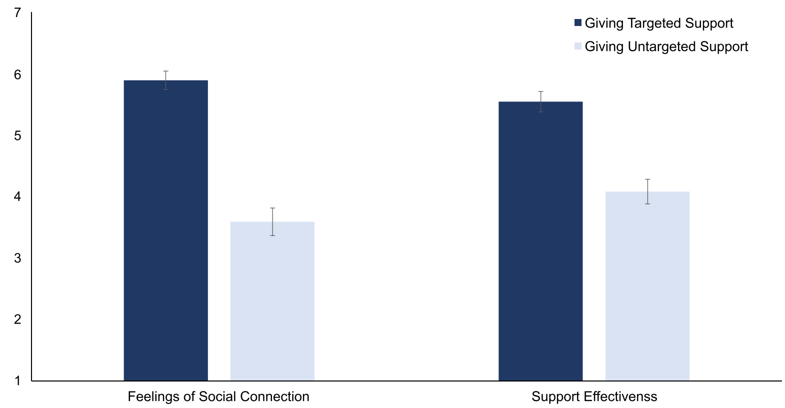

FIGURE 2. Self-reported feelings to giving targeted and untargeted support. In study 1, feelings of social connection and feelings that the support was effective in helping the target were greater when participants gave targeted (versus untargeted) support. Error bars represent standard errors. Color image is available only in online version (http://www.psychosomaticmedicine.org).

TABLE 1. Neuroimaging Results: Main Effects from Giving Support Task (Study 1, $n = 45$)

Anatomical ROI	M	SD	t	df	95% CI
Ignoring Target of Support					
Giving versus control					
Left VS	.42	.80	3.41*	41	.16 to .66
Right VS	.57	.68	5.38*	41	.36 to .76
SA	1.31	1.83	4.66*	41	.77 to 1.86
Giving versus self-reward					
Left VS	.41	.88	3.00*	41	.16 to .65
Right VS	.44	.86	3.31*	41	.21 to .70
SA	1.36	1.81	4.87*	41	.85 to 1.87
Giving targeted versus untargeted support					
Giving versus control					
Left VS	−.31	1.85	1.08	41	−.90 to .22
Right VS	−.34	1.78	1.24	41	−.99 to .19
SA	−1.24	3.41	2.36*	41	−2.56 to −.30
SA (outliers removed)	−.32	1.46	1.25	31	−.83 to .15
Giving versus self-reward					
Left VS	−.21	1.99	.68	41	−.86 to .36
Right VS	−.12	2.03	.37	41	−.77 to .46
SA	.13	2.76	.30	41	−.92 to .88
SA (outliers removed)	.58	1.51	2.17*	31	.05 to 1.14

ROI = region of interest; VS = ventral striatum; SA = septal area; M = mean; SD = standard deviation; t = t score from paired samples t test; df = degrees of freedom; CI = confidence interval.

*Significant, $p < .05$.

SA to giving support would be negatively correlated with amygdala activity to a separate task. As hypothesized, SA activity to giving targeted support (giving versus control) was negatively correlated with amygdala activity (negative versus nonnegative faces) such that greater SA activity to giving targeted support to close others was associated with less amygdala activity (r *right* = −.297, $p = .030$, 95% CI = −.547 to −.043, r *left* = −.256, $p = .053$, 95% CI = −.450 to −.072). SA activity to giving untargeted support was not associated with amygdala activity (r *right* = .084, $p = .30$, 95% CI = −.186 to .300; r *left* = .065, $p = .343$, 95% CI = −.145 to .246). Furthermore, the correlation between SA activity to giving targeted support and amygdala activity was different from the correlation between SA activity to giving untargeted support and amygdala activity (z *right* = 1.798, $p = .036$; z *left* = 1.502, $p = .067$), suggesting that the hypothesized association between the SA to giving support and amygdala may be specific to giving targeted support. Correlational results become stronger when removing those participants who accepted less than five offers per condition (r *right* = −.397, $p = .014$, 95% CI = −.682 to −.038; r *left* = −.422, $p = .009$, 95% CI = −.641 to −.224) (Figure 3).

VS to giving targeted support and amygdala activity were trending in the same direction as those above, but were not significant (r's between −.242 and − .175, p's > .063). VS to giving untargeted support was not related to amygdala activity (p's > .426).

Study 2

METHOD

Participants

A total of 490 individuals from the Adult Health and Behavior project, phase-II (AHAB-II), recruited by mass-mail advertising, participated in a study on the biobehavioral correlates of cardiovascular disease risk. Full sample and method details have been reported elsewhere (30). None of the reported measures have been published elsewhere. The AHAB-II data set provides a unique opportunity to replicate and extend the finding from study 1 in the following three ways: (*a*) to confirm whether giving targeted support is negatively correlated with amygdala activity, in a larger, more representative sample, (*b*) to examine whether self-reports of giving targeted and untargeted support (individual differences) relate to amygdala activity, and (*c*) to adjust for potential confounding social factors also theorized to relate to amygdala activity.

Participants were screened for general health, claustrophobia, and metal in the body. From the full sample, 384 participants (M age = 43.03, age range = 30–54 years, 197 females) who completed both the giving support measure and emotional faces task in the fMRI scanner were evaluated. Procedures were run in accordance with the University of Pittsburgh's Institutional Review Board. Participants provided written consent before completing study procedures.

Self-Report Measures

Giving Support

Giving targeted and untargeted support was assessed with the Self-Reported Altruism Scale (31). Participants reported on the frequency they gave support to others (1 [never] to 5 [often] scale). For the current study, items reflecting targeted and untargeted support were evaluated separately. Example items of giving targeted support include “I have given money to a stranger who needed it (or asked me for it)” and “I have offered my seat on a bus or train to a stranger who was standing” ($\alpha = .83$). Examples of giving untargeted support include “I have given money to charity” and “I have done volunteer work for charity” ($\alpha = .68$). Reports of giving targeted and untargeted support were moderately correlated ($r = .49$), suggesting that these forms of support are related but separate. Participants reported giving less targeted (M (SD) = 3.07 (.03)) than untargeted support (M (SD) = 3.37 (.04), $t(381) = 8.78$, $p < .001$). Two outliers greater than 3 SD's below the mean were removed from the sample, but results remain with the outliers retained. Results are based on a final sample of 382 participants.

Receiving Support

There is a large literature on the perceived availability of receiving support from others and emotion regulation (32). Therefore, receiving support was evaluated as a covariate to better isolate the unique associations between giving targeted support and amygdala activity. Receiving support was assessed with the 12-item Interpersonal Support Evaluation List (33) (M (SD) = 29.99 (4.90)), a scale widely used to assess the perceived availability of receiving support from others.

Social Integration

Social network size and diversity were evaluated with the Social Network Index (34) as additional covariates because objective indicators of support networks are associated with amygdala volume (35). Social network size was computed based on a sum of all individuals with whom one had contact with at least once every 2 weeks (M (SD) = 21.31 (8.74), range = 2–53). Network diversity was calculated from the sum of participation in high contact social roles (e.g., spouse, parent, friend, etc; M (SD) = 6.18 (1.98) of 12).

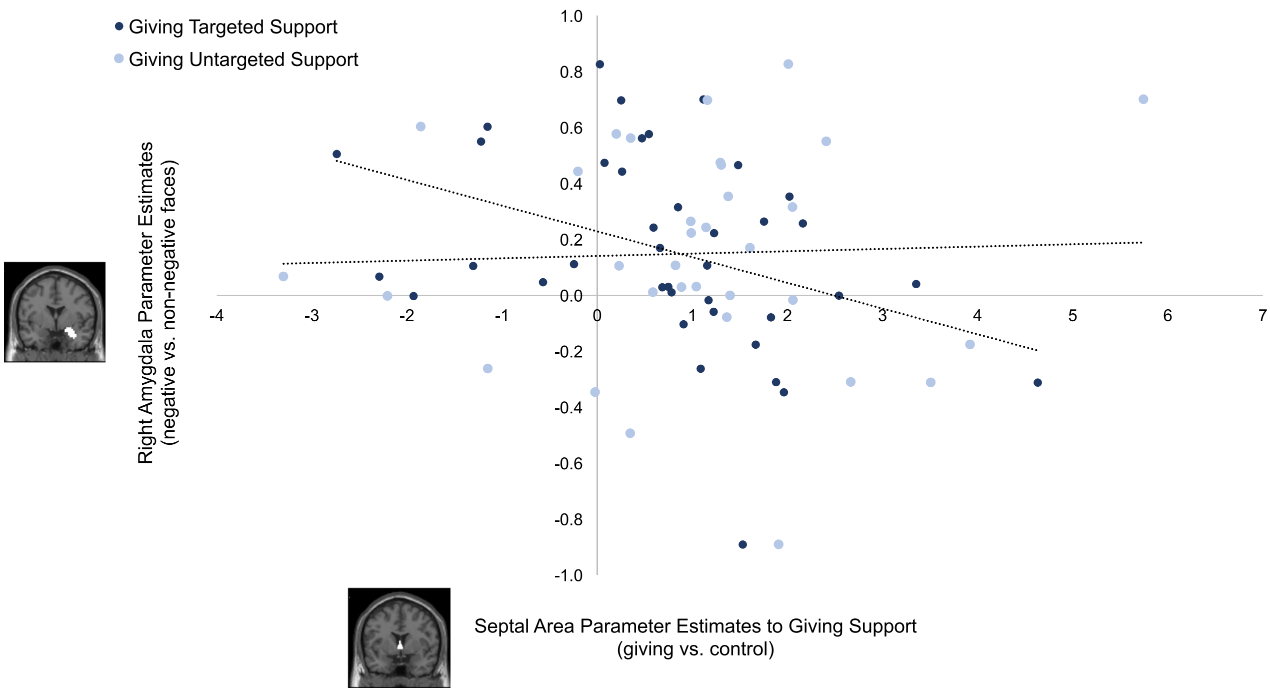

FIGURE 3. Correlations between SA to giving support and right amygdala activity to emotional faces task from study 1. Consistent with an inhibitory relationship between the SA and amygdala, greater SA to giving targeted support to a close other was associated with less right amygdala activity. SA to giving untargeted support was not associated with right amygdala activity, suggesting the benefits of giving support may be specific to giving targeted support. Results shown with participants who accepted less than 5 offers per giving condition removed, but results hold with all participants included. Color image is available only in online version (http://www.psychosomaticmedicine.org).

Neuroimaging Measure

Emotional Faces Task

The main aim of study 2 was to assess individual differences in giving targeted support and amygdala activity to a different emotional faces task. Thus, participants completed a standardized task that reliably elicits amygdala activity (36,37), has been shown to have good test-retest reliability (38), and has previously been associated with health (39). In a block design, participants viewed four blocks of a facial expression matching task (2 blocks each of anger and fear) interleaved with five blocks of shape-matching control. On each trial, a target face or shape appeared on the top of the screen and two additional faces or shapes at the bottom of the screen. Participants then indicated the face or shape that matched the target face or shape by selecting a button that corresponded to the position on the screen (right or left). Face-matching blocks contained six trials, presented for 4 seconds each with jittered fixation of 1.5 to 5.5 seconds. Shape-matching blocks contained six trials, presented sequentially for 4 seconds each.

fMRI Data Acquisition

MRI data were collected on a 3T Trio TM scanner (Siemens, Erlangen, Germany). A T_2-weighted anatomical scan was acquired by the following parameters: TR = 3000 milliseconds, TE = 11/101 milliseconds, flip angle = 150°, matrix = 256 × 256, 36 slices, 3 mm thick, FOV = 200 × 200 mm. Functional BOLD images for the emotional faces task were then acquired (FOV = 200 × 200 mm, matrix = 64 × 64, TR = 2000 milliseconds, TE = 29 milliseconds, flip angle = 90°, 3 mm) for a total duration of 5 minutes, 44 seconds.

Statistical Analyses

Imaging data were preprocessed and analyzed with SPM8. For preprocessing, images were realigned to the first image of the run by a six-parameter rigid-body transformation, co-registered to each participant's T_2-weighted structural image and then normalized by a 6-mm full width at half maximum Gaussian kernel. Linear contrast images from each participant (face-matching vs. shape-matching (36)) were estimated and then submitted to group-level, one-sample t tests. Parameter estimates from the structural amygdala ROI used in study 1 were extracted using Marsbar.

Correlations between giving targeted support and amygdala activity and giving untargeted support and amygdala activity were entered separately in SPSS v.24. Then, associations between giving targeted support and amygdala activity, adjusting for other social factors (i.e., receiving support and social integration), were evaluated with partial correlations.

RESULTS

Associations Between Self-reported Giving Support and Emotional Faces Task

In a conceptual replication of the result from study 1, self-reports of giving targeted support were negatively correlated with amygdala activity to negative faces (versus shapes; r *right* = −.112, p = .014, 95% CI = −.202 to −.016; r *left* = −.070, p = .086, 95% CI = −.152 to .019) (Figure 4). In other words, greater self-reports of giving targeted support to a single individual in need were associated with less amygdala activity.

Similar to study 1, giving untargeted support was not associated with amygdala activity (r *right* = −.044, p = .19, 95% CI = −.141 to .064; r *left* = −.031, p = .27, 95% CI = −.130 to .072). The correlation between giving targeted support and amygdala activity was marginally different from the correlation between giving untargeted support and amygdala activity for the right amygdala (z = 1.354, p = .088), but not the left (z = .772,

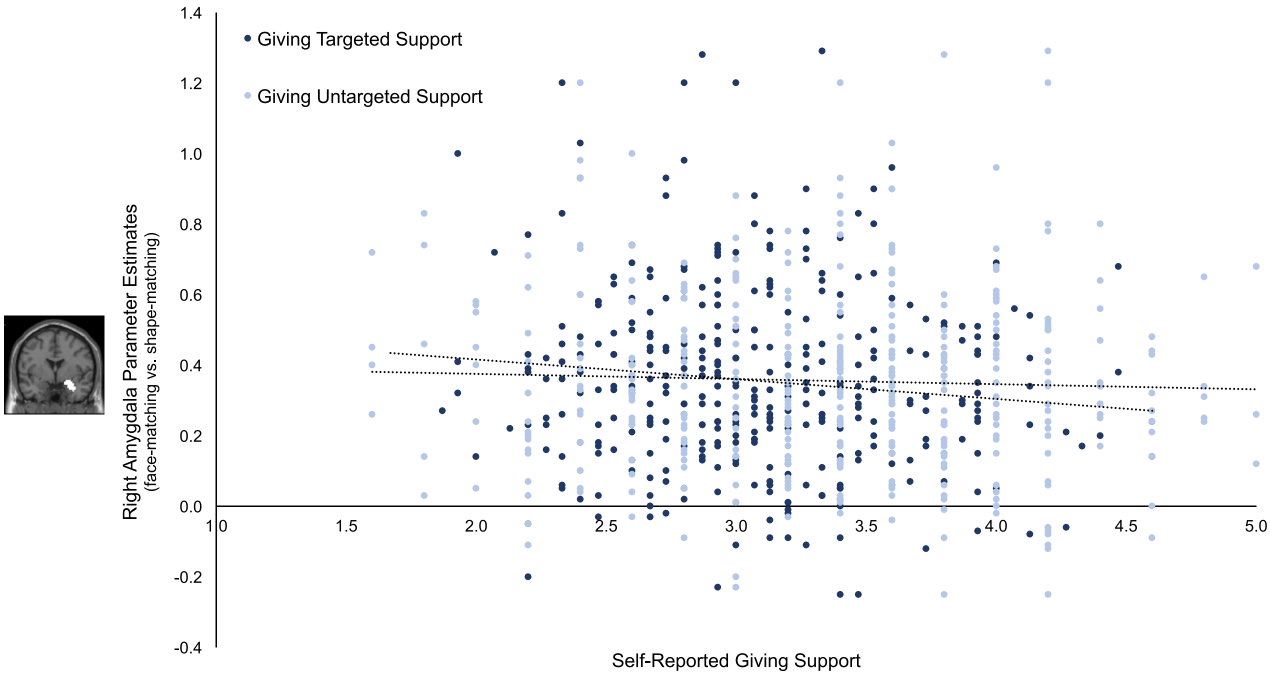

FIGURE 4. Scatter plot depicting correlations between self-reported giving support and right amygdala activity to emotional faces task from study 2 (n = 382). Replicating and extending the result from study 1, greater self-reports of giving targeted support were associated with less right amygdala activity. Results hold after adjusting for potential confounding social factors (receiving support and social integration). Self-reports of giving untargeted support were not related to amygdala activity. Color image is available only in online version (http://www.psychosomaticmedicine.org).

p = .22). Although marginal, the difference between the two correlations suggests relationships between individual differences in giving support and amygdala activity may be specific to targeted support.

Associations Between Self-reported Giving Support and Emotional Faces Task Adjusting for Receiving Support and Social Integration

Next, the association between self-reported giving targeted support and right amygdala activity to the emotional faces task (face-matching versus shape-matching) was examined, adjusting for other subjective (receiving support) and objective (social integration) social factors theorized to relate to amygdala activity. The correlation between giving targeted support and right amygdala activity remained significant when adjusting for receiving support, social network size, and social network diversity (r = −.105, p = .021, 95% CI = −.200 to −.011). Thus, the negative correlation between self-reports of giving targeted support to an identifiable individual in need and right amygdala activity to negative faces remained when other indicators of the quality of one's social world were held constant.

DISCUSSION

Giving support can benefit the health of the individual giving, but the neural mechanisms that contribute to giving support are not well understood. We have proposed that two pathways contribute to giving support: (*a*) those that reinforce giving support behavior and (*b*) those that reduce withdrawal to facilitate care (5,6). Furthermore, our theoretical perspective suggests that giving targeted support to an identifiable individual in need may lead to the greatest benefits. The current studies examined self-reported feelings and neural activity to giving targeted and untargeted support. In support of hypotheses, giving targeted (versus untargeted) support resulted in greater feelings of social connection and feelings that the support was effective. Second, giving targeted support was negatively correlated with amygdala activity to negative faces across two independent samples. In study 1, SA to giving targeted support to a close other in need was associated with less amygdala activity to an emotional faces task. In an extension and conceptual replication of this result, study 2 showed that greater self-reports of giving targeted support to a stranger in need was also associated with less amygdala activity to a different emotional faces task, even when adjusting for social factors thought to relate to amygdala activity (i.e., receiving support, social network size, social network diversity). For both study 1 and study 2, the same associations with amygdala activity were not shown for giving untargeted support to charities, suggesting that giving targeted support may be uniquely beneficial.

We and others have suggested that the human capacity to give support to others stems from the care provided to infants (4–6,40,41). That is, supportive behavior may have originally evolved to ensure that single, identifiable targets in need (i.e., offspring) survive. The mechanisms theorized to support such care may therefore be particularly relevant to giving targeted support. Hence, although it may "feel good" to give support in general, a viewpoint suggested by the "warm glow" account of giving (21), it is potentially the support that is targeted that most rely on the proposed mechanisms. Indeed, study 1 showed that feelings of social connection and support effectiveness, two psychological factors that reinforce giving support (42), were greater when participants gave targeted (versus untargeted support). Similarly, SA to giving targeted support was greater than SA to giving untargeted support. However, the SA finding was only true for the comparison of giving to self-reward and only after removing outliers. Furthermore, the finding from study 1 that giving targeted and untargeted support similarly activates the VS suggests that giving support, regardless of the target, can be reinforcing. This finding supports both the "warm glow" account of giving and our theoretical perspective to suggest that giving support to others more broadly (i.e., giving to both abstract and individual needs) seems to activate the VS more than receiving for the self. More research is needed before concluding that there are reliable differences in neural responding between giving targeted and untargeted support.

The negative association between SA activity to giving targeted support and amygdala activity to emotional faces suggests a neural pathway by which giving support may ultimately influence health. In animals, electrical stimulation of the SA inhibits sympathetic nervous system–related responding (43,44). In humans, the amygdala likewise shares connections with downstream physiological responding (45). The current findings suggest associations between the SA to giving targeted support and amygdala may also extend to subsequent negative stimuli. Although physical health outcomes were not directly assessed, recent experimental findings outside of the brain are consistent with the hypothesis that giving targeted support affects physical health. Giving targeted support to someone else in need (versus control conditions) causes reductions in sympathetic nervous system–related responding to a psychosocial stressor (19) and lower resting blood pressure (study 2: 2). In addition, random assignment to 4 weeks of giving targeted support (versus giving untargeted support to charities) results in better inflammatory gene expression profiles (46). Taken together, results suggest that giving targeted support may be particularly relevant to health via an inhibitory SA-amygdala relationship.

A limitation of the current results is that they are correlational, and thus, we interpret the causal role of giving support on amygdala activity with caution. Indeed, causation cannot be determined based on these results alone. Additional work is also needed to rule out third variables that may also affect amygdala activity to negative facial expressions other than those evaluated in study 2.

The current findings suggest that giving targeted support might be particularly beneficial, but not all targeted support is associated with health. A considerable body of research shows that prolonged caregiving for an ill family member, an extreme case of giving targeted support, is detrimental to health (47), although recent views challenge the view that caregiving is necessarily detrimental (48). The conditions (e.g., free choice in the support given, how effective one feels their support was) under which support is beneficial for health are therefore important to consider in future work to better understand giving support and health (5,6).

In summary, an accumulating literature suggests that giving support may be an overlooked contributor to the well-known link between social ties and health. The current studies examined neural mechanisms related to parental care in animals that may both reinforce care and reduce withdrawal to giving targeted and untargeted support. Results suggest that giving targeted support to an identifiable individual in need is uniquely associated with reduced amygdala activity, thereby contributing to understanding of how and when giving support may lead to health.

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