NeuroImage 128 (2016) 1–10

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/ynimg

The effects of gratitude expression on neural activity

Prathik Kini, Joel Wong, Sydney McInnis, Nicole Gabana, Joshua W. Brown *

Indiana University, Bloomington, United States

ARTICLE INFO

Article history:
Received 23 July 2015
Accepted 23 December 2015
Available online 30 December 2015

Keywords:
Gratitude
fmri
Plasticity
Counseling
Empathy

ABSTRACT

Gratitude is a common aspect of social interaction, yet relatively little is known about the neural bases of gratitude expression, nor how gratitude expression may lead to longer-term effects on brain activity. To address these twin issues, we recruited subjects who coincidentally were entering psychotherapy for depression and/or anxiety. One group participated in a gratitude writing intervention, which required them to write letters expressing gratitude. The therapy-as-usual control group did not perform a writing intervention. After three months, subjects performed a "Pay It Forward" task in the fMRI scanner. In the task, subjects were repeatedly endowed with a monetary gift and then asked to pass it on to a charitable cause to the extent they felt grateful for the gift. Operationalizing gratitude as monetary gifts allowed us to engage the subjects and quantify the gratitude expression for subsequent analyses. We measured brain activity and found regions where activity correlated with self-reported gratitude experience during the task, even including related constructs such as guilt motivation and desire to help as statistical controls. These were mostly distinct from brain regions activated by empathy or theory of mind. Also, our between groups cross-sectional study found that a simple gratitude writing intervention was associated with significantly greater and lasting neural sensitivity to gratitude – subjects who participated in gratitude letter writing showed both behavioral increases in gratitude and significantly greater neural modulation by gratitude in the medial prefrontal cortex three months later.

Introduction

Gratitude is an essential part of human prosocial behavior. A number of recent studies have shown the benefits of gratitude interventions on well being, mainly using gratitude letter writing or keeping a gratitude diary, both of which can be effective (Kaczmarek et al., 2015). Gratitude interventions have recently been shown as effective at increasing well being in students (Flinchbaugh et al., 2012), those with chronic pain (Baxter et al., 2012), depression (Cheng et al., 2015), and older adults (Killen and Macaskill, 2015). Gratitude interventions have similar effectiveness compared with mindfulness interventions (O'Leary and Dockray, 2015) and practicing kindness (Kerr et al., 2015).

Despite the recent findings regarding gratitude intervention effectiveness, the basic neural mechanisms involved in gratitude are relatively unknown, as are the neurological mechanisms mediating the effects of gratitude interventions (Layous et al., 2011). On the one hand, gratitude may involve *affective* processes. Gratitude has been characterized as a positive moral affect alongside other moral affects such as empathy, sympathy, guilt, and shame, and as a force that helps people maintain positive social reciprocity (McCullough et al., 2001). On the other hand, other work has cast gratitude as related to a more *cognitive* process of benefit appraisal (Wood et al., 2008).

Gratitude may also be delineated in terms of *experience* vs. *expression*. The recipients (or observers) of a generous or prosocial act may experience emotions related to gratitude, such as positive affect, empathy, and increased inclination toward prosocial behavior (Emmons and Stern, 2013). The experience of gratitude may naturally lead to an expression of gratitude, which typically takes the form of a verbal recognition ("thank you") or a reciprocal gift (such as generous restaurant tipping). In this paper we address both experience and expression of gratitude in three inter-related ways. First, subjects in an experimental group express gratitude in the form of a written letter three months prior to fMRI scanning. Second, during scanning, we model gratitude as an expression, with monetary gifting as a quantifiable operationalization of gratitude expression. Third, during scanning, we also ask subjects to evaluate their experience of gratitude on each trial, with self-reports on a Likert scale.

Gratitude has been studied with neuroimaging as part of more general investigations of human social value (Zahn et al., 2009), but the specific neural correlates of gratitude have only recently been explored (Fox et al., 2015). A number of similar social cognitive and affective constructs have been studied, including trust and reciprocity (King-Casas et al., 2005), fairness (De Quervain et al., 2004; Sanfey et al., 2003), and empathy (Singer et al., 2004, 2006). Collectively these studies highlight a number of brain regions as central to social interaction, including prominently the anterior cingulate cortex (ACC), anterior insula (AI), ventromedial prefrontal cortex (vmPFC), and striatum, which are generally limbic regions associated with affect and valuation. The anterior

* Corresponding author at: Dept. of Psychological and Brain Sciences, 1101 E Tenth St., Bloomington, IN 47405-7007, United States.
E-mail address: jwmbrown@indiana.edu (J.W. Brown).

http://dx.doi.org/10.1016/j.neuroimage.2015.12.040
1053-8119/

cingulate cortex in particular may play a key role in predicting and evaluating the outcomes of actions (Alexander and Brown, 2010, 2011), including in social contexts (Chiu et al., 2008; King-Casas et al., 2005; Tomlin et al., 2006). ACC activity reflects and drives avoidance behavior, especially of potential losses (Brown and Braver, 2007; Fukunaga et al., 2012) as well as potential regret (Coricelli et al., 2005) and social affect (Harris et al., 2007), and has been shown to correlate with empathy (Rameson et al., 2012), especially for pain (Singer et al., 2006). If gratitude involves primarily an affective process, then gratitude expression should correlate with activity in the limbic regions.

Gratitude may also involve cognitive processes, including computations and appraisals of appropriate reciprocity (Wood et al., 2008). Mental calculations generally involve more dorsolateral prefrontal and parietal brain regions (Dehaene et al., 2004). Thus, if gratitude involves more cognitive than affective processes, then gratitude expression should correlate with activity in the parietal and dorsolateral prefrontal regions.

In addition to questions about the basic neural mechanisms of gratitude, there is potential clinical relevance. Growing evidence supports the mental health benefits of gratitude interventions (e.g.Boehm et al., 2011; Emmons and McCullough, 2003; Froh et al., 2008; Lyubomirsky et al., 2011; Seligman et al., 2005; Sheldon and Lyubomirsky, 2006; Watkins et al., 2003). Research on such interventions has focused mainly on non-clinical populations (e.g., college and high school students). Still, the basic neural mechanisms through which gratitude interventions might positively influence mental health are not well understood. Several mechanisms have been proposed (Emmons and Mishra, 2012; Geraghty et al., 2010) but only one peer-reviewed study so far has identified a mediator (i.e., feelings of gratitude) of the positive effects of a gratitude intervention (Emmons and McCullough, 2003).

Here our aim is to elucidate specifically the basic neural correlates of gratitude expression, and we do not investigate or report clinical effects. Our study focuses on four related questions: first, what are the immediate neural activity correlates associated with acts of expressing gratitude (operationalized as monetary gifts)? Second, is the neural activity more consistent with gratitude as a cognitive process or as an emotional process? Third, to what extent does gratitude expression involve the brain regions associated with empathy and theory of mind processes? Fourth, what are the long-term effects of written gratitude expression (as distinct from grateful monetary gifting) on neural sensitivity to gratitude?

To address these questions, we developed a variant of the trust game (Berg et al., 1995), called the "Pay It Forward" task, in which subjects express gratitude as monetary gifts while undergoing fMRI. We administered a short gratitude writing intervention to half of the subjects and explored the effect of that intervention on brain activity during the gratitude task several months later. This approach allows us to measure both the immediate neural activity associated with gratitude and the lasting effects of gratitude expression on brain activity. Here we show two main results: first, that gratitude correlates with activity in specific set of brain regions; and second, that a simple gratitude writing intervention is associated with significant increases in both gratefulness and neural sensitivity to gratitude over the course of weeks to months.

Methods

Subject recruitment

Subjects were recruited from a population of psychotherapy clients seeking clinical counseling. All subjects provided written informed consent, and all procedures were approved by the Indiana University IRB. Subjects were randomized to one of three conditions: a gratitude writing intervention, an expressive writing intervention, or a psychotherapy-only condition. The randomization was performed with successive subjects to keep the running group sizes as equal as possible, without regard for particular demographic factors. Subjects initially completed the six-item Gratitude Questionnaire (GQ) (Mccullough et al., 2002), the three-item gratitude adjectives scale (GAC3) (Mccullough et al., 2002), which assess self-reports of how grateful one feels in daily life, and the BHM-20 scale, which briefly assesses mental health, including anxiety and depression (Kopta and Lowry, 2002). Higher BHM-20 scores reflect better mental health. For the gratitude writing intervention, subjects were asked to spend 20 min writing a letter to someone expressing gratitude. They did this during three consecutive sessions on the first, second, and third week of counseling. They were instructed that they could choose whether or not to actually send the letters to the recipient. Subjects in the expressive writing condition were asked to write about their most stressful episodes in life. Three months after counseling, the gratitude writing and psychotherapy-only subjects were recruited to participate in the fMRI task.

A total of 43 clients (22 in the gratitude intervention condition and 21 in the psychotherapy only condition, age range 18 to 34, mean 22.98, 32 females, all right handed) were recruited for the fMRI study. We did not scan the expressive writing subjects for cost reasons, although future studies might consider doing so as an additional control. The subject demographics are summarized in Table 1. There was no difference between the fMRI gratitude writing vs. psychotherapy-only groups with respect to their age ($p = 0.50$), gender ($p = 0.73$) initial GQ (trait gratitude) scores ($p = 0.41$), or symptoms of anxiety/depression as measured on the BHM-20 symptom subscale ($p = 0.55$). The average BHM-20 score at intake was 2.39 for the gratitude group and 2.50 for the therapy-as-usual group (Table 1), which is consistent with average scores of 2.33 for psychotherapy outpatients and 2.68 for college counseling clients, as reported by the BHM-20 developer (Kopta and Lowry, 2002), who also reported for comparison that the average healthy college student BHM-20 score was 3.13 ($SD = 0.51$). Lower BHM-20 scores indicate more symptoms of anxiety and/or depression.

fMRI task

In order to perform the study in a controlled setting, the expression of gratitude was operationalized as money, with a function similar to tipping a restaurant server. To partly dissociate gratitude from guilt aversion, we modified the trust game (Berg et al., 1995) to make it a "Pay It Forward" (PIF) task (Fig. 1). In the PIF task, subjects acted as a Trustee, who received a sum of money between $1 and $20 from a benefactor, whose picture was shown on the screen. Subjects were told that the benefactor was a real person, not a computer, although the endowments were in fact determined by a computer. The subjects were then shown a potential third party beneficiary, with whom the trustee could share any portion of the endowment given by the benefactor. They were told that the benefactor did not want the money back, but that the benefactor wanted them to pass on what they had received if they felt that they wanted to express gratitude for the endowment. The beneficiary was said to not have immediate need of the money, but would nevertheless appreciate it. We could have quantified gratitude simply as a Likert rating, but we chose not to. Instead, we chose to operationalize gratitude here as money given, for several reasons. First, it renders gratitude quantifiable in terms of monetary value, which is necessary for the quantitative analyses we perform. Second,

Table 1
Demographics. Subjects showed no significant differences between groups regarding age, gender, initial gratitude (GQ), or initial anxiety/depression symptoms (BHM-20).

Variable	Gratitude	Control	P
Gender	F = 17, M = 5	F = 15, M = 6	0.73 (Fisher exact 2 sided)
Age (range 18–34)	23.41	22.52	0.50 (2 tailed)
GQ	5.38	5.67	0.41 (2 tailed)
Symptoms (initial BHM-20)	2.39	2.50	0.55 (2 tailed)