The Effects of Gratitude on Cortisol Reactivity

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Cortisol, a hormone released by the adrenal glands during periods of psychological or physiological stress, has been linked to many of the harmful effects of stress. If cortisol levels are not managed, individuals may be at higher risk of developing certain mental disorders, heart disease, and more. Research examining the effects of gratitude shows promising results in reducing psychological stress, but it is not known if this translates into the physiological effect of reduced cortisol production. This study tests the effect of a gratitude intervention on stress and cortisol levels in college students. In this experiment, a set of 38 participants listed three things they were grateful daily for 28 days and wrote a weekly paragraph about what they were grateful for to test if the intervention could improve cortisol reactivity, perceived stress, satisfaction with life, and gratitude. Cortisol reactivity was measured by salivary cortisol samples taken before and after a stressful social computer game. The hypothesis was not supported. Limitations and future research are discussed as to how gratitude interventions may be effective only under certain conditions.

Background

Stress is a common occurrence in our everyday lives. Some experience it more than others due to several factors including social economic status (SES) (Lupien, King, Meaney, & Mcewen, 2000), strained relationships with family or friends (Boey, 1998), and work environment (Nieuwenhuijsen, Bruinvels, & Frings-Dresen, 2010). Although many have a general idea of what stress is, its causes, effects, and how to prevent it are not fully understood. Fortunately, recent research has examined a technique of managing stress that does not require extra time, money, or energy—practicing gratitude towards current life experiences. To understand how gratitude may benefit those who are stressed, it is important to conceptualize what stress really is and why it needs to be managed.

Stress

A stressor can be defined as "an event that creates a sense of threat to a person with a demand or opportunity for change of some kind" (Comer, 2015, p.638). A threat can

I have just recently graduated from the University of Hawai'i at Mānoa with an Honors BS in Psychology. My hopes are to go to graduate school to obtain my PhD in Health Psychology and to pursue research in psychoneuroimmunology. This article is part of my thesis entitled "The Effects of Gratitude on Cortisol Reactivity." My main goal for this project was to explore how gratitude may be used to prevent overstimulation of the Hypothalamic-Pituitary-Adrenal axis. Unfortunately, the results did not support the hypothesis. Although I was first disappointed with the findings, I was comforted by the fact that science was created to test our assumptions rather than try to confirm them. With that I continued my efforts to try and publish this article and have succeeded, and hopes are that I can publish more of my research in the future.

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manifest as a physiological, psychological, or social phenomena (Comer, 2015). Although these phenomena can be thought of separately, they often co-occur. Physiological stress, such as becoming sick with a fever, can often lead to psychological stress related to missing work. Social stress activates the Hypothalamic-Pituitary-Adrenal axis (HPA-axis) to release cortisol, which will be discussed below. Being that stress intertwines with so many aspects of our lives, it is important to understand what it does, how it affects people, and by what methods it may be prevented. An individual's reaction to stress is difficult to predict. Some thrive on it while others crumble (Habra, Linden, Anderson, & Weinberg, 2003).

Personality type plays a role in reactivity to psychological stress (Habra et al., 2003). Those with a Type D personality type have been shown to react to stress more intensely. Type D personalities often feel more negative emotions and are anxious or fearful of social situations. When personality traits were considered independently of each other, social inhibition was associated with heightened systolic blood pressure (SBP), diastolic blood pressure (DBP), and reactivity to laboratory stress. Those with both characteristics of a Type D personality had greater cortisol reactivity, a stress hormone response (Habra et al., 2003). In all, stress appears to affect individuals in differing ways. If left untreated, it can interfere with long-term goals such as maintaining a healthy lifestyle, resulting in unhealthy behaviors. Ng and Jeffery (2003) found that high stress was correlated with higher fat diets, less frequent exercise, and increase in smoking behavior as well as less self-efficacy to quit smoking (Ng & Jeffery, 2003). Being that stress can impair behavioral aspects of health, it is critical to determine a healthier coping mechanism that can benefit a range of stress responses.

Behavioral and biological factors can be altered to decrease the likelihood of developing these debilitating disorders. For example, Cognitive Behavioral Therapy for the Treatment of Insomnia (CBT-I) and Mindfulness-Based Stress Reduction (MBSR) have been show to significantly improve stress levels measured by the Calgary Symptoms of Stress Inventory (Garland et al., 2014), supporting the notion that changing thought patterns can reduce stress. Psychological stress translates to physiological stress, as it manifests through biological pathways that include the hormone cortisol. Cortisol in small doses helps the body become alert to threats, but may in fact harm us in the long-run if not properly managed.

Cortisol and HPA-Axis Function

Cortisol is a hormone regulated by the HPA-axis. When the brain perceives a stressful event, the hypothalamus releases corticotrophin releasing hormone (CRH) to the anterior pituitary gland, which then sends out adrenocorticotropic hormone (ACTH) to the adrenal gland, signaling it to release cortisol. This system has a negative-feedback loop. Once cortisol has been released into the bloodstream, it binds to glucocorticoid receptors in the hypothalamus, and the hypothalamus stops releasing CRH. This results in cessation of cortisol release. If cortisol is released too often, the glucocorticoid receptors in the hypothalamus become desensitized to cortisol and the hypothalamus will continue to release CRH to the anterior pituitary resulting in cortisol being continually released. This is known as exhaustion of the HPA-axis. Once the mechanism to regulate cortisol has been desensitized, this excess cortisol begins to show lasting consequences on both health and mental well-being. As an early marker of potential deregulation of the HPA-axis, measures of cortisol are a good way to assess the relationships between psychological stress and physical health. One method to measure HPA-axis deregulation is cortisol reactivity. Cortisol reactivity is a measure of how much cortisol gets released into the bloodstream when exposed to a stressful situation. In those with a normal cortisol reactivity response, cortisol has a low baseline level, increases during the stressful event, and then returns to the low baseline once the stressor is gone. If the receptors in the hypothalamus become desensitized and the HPA-axis has exhausted its resources, this cortisol reactivity becomes blunted. Thus, cortisol does not increase in response to a stressor. This is considered an unhealthy cortisol reactivity response, and is associated with the many health risks like Cushing's syndrome, cardiovascular disease, and more (Whitworth, Williamson, Mangos, & Kelly, 2005). Each of these conditions lead to a poorer quality of life and, over time, can become deadly. Therefore, it is important to understand who may be at risk of an exhausted HPA-axis and how stress can result in this exhaustion.

Like Habra and others' findings (2003), Kirschbaum and others (1995) found that some personality characteristics are predictive of cortisol hyperactivity responses, or in other words, high cortisol reactivity. After putting 20 healthy men through a stressful task, a third of the men displayed cortisol hyperactivity responses on day 1, compared to other individual baseline levels. The other

two thirds of the group showed an increase in cortisol in response to the stressor, but a slightly smaller rise in cortisol compared to the high responders group. Participants who had similar psychological profiles as patients diagnosed with anxiety or depression had a larger cortisol release response on day 1 and continued to show a significant rise in cortisol in response to the stressor, while the other two groups did not show a significant rise in cortisol over the next four stressor sessions. Those categorized as low responders did not share that same psychological profile (Kirschbaum et al., 1995), suggesting that some are more at risk of developing stress related illnesses as well as mood and anxiety disorders.

The Effect of Mood Disorders on HPA-Axis Function

Past research has shed light on the relationship between mood disorders and HPA-axis functioning. Goodyer, Tamplin, Herbert, and Altham (2000) looked at how and/or if life events and cortisol can predict the onset of major depressive disorder (MDD) in high-risk adolescents. Undesirable life events, disappointment, and permanent loss contributed to the onset of MDD if they occurred in the preceding month. In a normal cortisol awakening response (CAR), cortisol spikes when the individual is waking up and slowly decreases throughout the day and is at its lowest before falling asleep (Kamin & Kertes, 2017). The occurrence of abnormally high peaks in morning CAR is predictive of subsequent MDD in high-risk adolescents (Goodyer et al., 2000). Vreeburg and others (2013) found that a lower CAR was associated with the development of depression and anxiety (Vreeburg et al., 2013). It appears these adverse life events cause the HPA-axis to go into overdrive and release cortisol at a constant rate leading to exhaustion of the HPA-axis, resulting in flatter diurnal cortisol slopes later on. To stop the development of depression and anxiety, coping mechanisms to decrease stress should be investigated. Emotion based coping may be the answer for stressors with no clear solution. Past research is beginning to show that gratitude and stress may have a negatively correlated relationship, making it a potential candidate for managing stress.

Gratitude

The concept of gratitude is typically divided into two distinct categories: expression and experience (Wood, Froh, & Geraghty, 2010). Expressing gratitude is letting an individual know they are appreciated for what they have contributed to the world or to the one expressing the gratitude. Expressing gratitude is restricted to only other individuals and does not encompass the full spectrum that can come with this emotion. Experiencing gratitude, on the other hand, is the appreciation of any and/or all aspects of life. This allows for an individual to have an all-encompassing view of the positive aspects of his or her life, rather than it being constricted to just another individual. What these two categories do share is the conscious awareness and evaluation of the positive aspects of another person or aspects of their life. Therefore, our experiment focuses on the effects of cultivating the experience of gratitude rather than expressing gratitude. By bringing awareness to these observations, individuals may be able to reap the benefits of the Broaden-and-Build Theory developed by Barbara Fredrickson (Fredrickson & Branigan, 2005).

The Broaden-and-Build Theory states that positive emotions broaden an individual's thoughts, attention, cognition, and possible actions compared to a neutral state (Fredrickson & Branigan, 2005). When one experiences negative emotions, those same thoughts and actions become narrowed, most likely to address a threat present at the time being. Evolutionarily, the narrowed thought-action repertoires of negative emotions were most likely used to address immediate threats, while the broadened thought-action repertoires were adaptive for long-term use. The broadened repertoire can include physical ability, social resources, intellectual resources, and psychological resources. The theory states that these resources obtained during positive emotional states can be used later when needed and are in a sense durable, meaning they can last through other non-positive emotional states. In all, the broadening of personal resources during positive states helped our ancestors survive and become adaptive (Fredrickson & Branigan, 2005).

Fredrickson and Branigan (2005) conducted two experiments that supported this theory. In one of their experiments, participants who experienced positive emotions were more likely to have a higher number of responses to a Twenty Statement Test, compared to those experiencing no particular emotion. The Twenty Statement Test is a test in which participants are asked to relive a particular emotion and then write down as many things they wish to do at that moment because of that emotion. In the other experiment, participants who experienced positive emotions elicited through short films showed a broader scope of attention when compared

to films that elicited no particular emotion. This would indicate a broadening of thoughts and possible actions (Fredrickson & Branigan, 2005). Being that gratitude is a positive emotion or at least an experience that elicits positive emotions (e.g. awe, joy, etc.), gratitude can be assumed to have these same affects. If practiced enough, gratitude interventions may allow individuals to better adapt to difficult situations, and potentially reduce stress by comparing the impact of a stressor to other positive aspects of their life and lessen the perceived impact that stress has on their life, thus bringing a practical cognitive appraisal of the situation rather than exacerbating it. Gratitude interventions not only improve one's coping mechanisms, they can have lasting effects on neural activity.

Kini, Wong, McInnis, Gabana, and Brown (2016) recruited participants when entering psychotherapy for depression and/or anxiety. One group was told to write letters of gratitude during the intervention and continue psychotherapy while a second group continued with only psychotherapy and acted as a control group. After three months, subjects performed a task in which they were given money and told to pass it on to a charitable cause to the extent they felt grateful for the gift while in a fMRI. Increased brain activity was found in areas that are correlated with the self-reported gratitude experience during the task in those who wrote letters of gratitude. They measured these against areas that are correlated with guilt motivation and desire to help as statistical controls, which are distinct from brain regions activated by empathy or theory of mind. They also showed greater neural sensitivity to gratitude, meaning they recognized when others were expressing gratitude with more ease when compared to the control group. Three months later they showed both behavioral increases in gratitude and greater neural activity to gratitude in the medial prefrontal cortex (Kini et al., 2016). The lasting effects of gratitude translate into an increase in well-being and may ease certain life burdens.

Leary, Dockray, and Hammond (2016) found that Gratitude during Pregnancy (GDP) scores were positively and significantly correlated with positive feelings, pregnancy uplifts and satisfaction with life, while negatively correlated to negative aspects of well-being including negative moods and pregnancy difficulties (Leary et al., 2016). Emmons and McCullough (2003) investigated the effects gratitude interventions had on a wide range of positive traits and subjective well-being. Participants who underwent a gratitude intervention felt better about their life overall, were more optimistic for the upcoming week, had fewer physical complaints, had improved sleep quality, and increase in the number of hours sleeping when compared to the hassles group. Those in the gratitude group showed positive behavioral changes as well. They exercised more and were more likely to report having helped someone with a personal problem or offered emotional support to someone. Many spouses or significant others noticed an improvement in their moods as well (Emmons & McCullough, 2003).

Some research questions the efficacy of gratitude interventions on well-being and other psychological markers. Davis and others (2016) conducted a meta-analysis on the gratitude interventions and found only a marginal benefit for gratitude interventions compared to matched-activity controls, defined as interventions with the same amount and type of work, but without the gratitude induction. They suggest that the benefit obtained from gratitude interventions might simply be a placebo effect. Limitations of the meta-analysis were that most of the experiments they reviewed were conducted on individuals who are already highly grateful, leaving less room to enhance gratitude. This may mean that gratitude interventions are simply more affective for those who are not grateful and at risk of depression or anxiety. Being that much of the research they examined was performed on highly grateful people, it is still possible that clinical use of these interventions could enhance the well-being of those seeking treatment.

Gratitude and Stress

Despite these criticisms, most the research seems to suggest that gratitude is an effective tool in managing stress. Wood, Maltby, Gillet, Linley, and Joseph (2008) found a direct model in which gratitude led to higher levels of perceived social support and lower levels of stress and depression during a life transition for young people living on their own in the first semester of college. No variable seemed to increase gratitude, suggesting a one-way relationship between gratitude and stress. Jackowska and others' (2015) study is one of the only studies to examine the relationship between gratitude and cortisol. They looked at how a gratitude intervention could affect the cardiovascular system, neuroendocrine system, and sleep. The gratitude group had improved sleep quality, reduced diastolic blood pressure, increased ability to feel joy and happiness, increased flourishing scores, optimism, and life satisfaction when compared to the control

group. The rest of the biological parameters did not improve with the intervention, including cortisol (Jackowska et al., 2015). Given these robust effects it is surprising that cortisol did not improve, however this may have been due to the relatively short two-week intervention period.

One mechanism to improve cortisol levels with gratitude is to enhance sleep quality. Nelson and Harvey (2003) found that negative thoughts were related to poor sleep quality while positive thoughts were related to improved sleep quality and quantity. Along the same line of research, Wood, Joseph, Lloyd, and Atkins found gratitude was related to total sleep quality, sleep duration (both insufficient and excessive sleep), subjective sleep quality, and daytime dysfunction from insufficient sleep (Wood et al., 2009). Leproult, Copinschi, Buxton, and Van Cauter (1997) found that cortisol increases after a night of either partial or total sleep loss while participants in the normal sleep schedule (eight hours of sleep) group did not have an increase cortisol level the next day (Leproult et al., 1997). Those that slept for a total of four hours had a 37% increase in cortisol the next day while those who did not sleep at all had a 45% increase in cortisol the next day (Leproult et al., 1997). By improving pre-sleep cognition, gratitude interventions may be able to indirectly decrease cortisol levels. This, of course, could only benefit those who do not receive enough sleep on a regular basis and has a limit of how much it can benefit people since once an individual receives enough sleep they are most likely not able to decrease cortisol levels below regular levels.

In summary, cortisol dysregulation appears to have a damaging effect that leads to both psychological and physical disease. Exhaustion of the HPA-axis seems to play a major role in developing these diseases, which is why it is important to understand methods to improve cortisol reactivity. Gratitude interventions may have the answer to managing stress, but current research has not fully explored the link between gratitude induction and cortisol reactivity. This research hopes to close this missing link in the research by examining the effects of the gratitude interventions on cortisol reactivity. Because a majority of college students can be categorized as moderately to highly stressed (Pierceall & Keim, 2007), we expect college students who practice a gratitude intervention will improve in their cortisol reactivity, showing a higher spike in cortisol in response to a stressor, decrease perceived stress, and increase Satisfaction with Life and Gratitude when compared to those who practice an activity matched control.

Method

Sample

Participants were recruited through a research methods class and were offered credit if they participated in the study. Participants gave informed consent and were provided with an alternate assignment if they did not want to participate in the research study. A majority of students chose to participate in the research (43 out of 53, 81.13%). Participants were mainly female (35 women, 7 men, 1 unidentified) and varied in age (Figure 1), but were mostly young adults. Ethnicity varied amongst participants (Figure 2), but were mainly Asian or Native Hawaiian. This gives a total of 43 participants who started out the study. Five participants dropped out of the study, leaving 38 participants. Outlier scores from one participant were

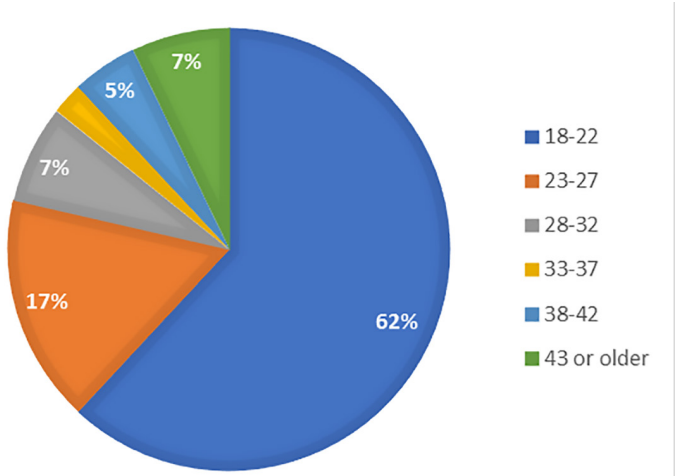

Figure 1 Percentage of participants in each age group.

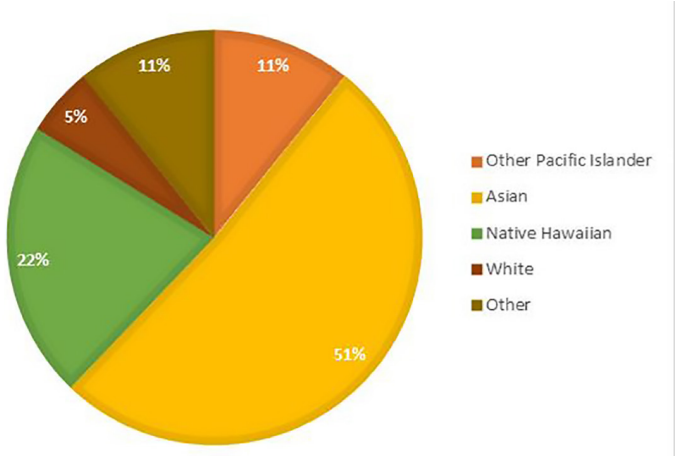

Figure 2 Percentage of participants in each ethnicity.

removed from data analysis. There were no restrictions placed onto who may participate in the study.

Materials

Video game stressor: SpaceTeam version 2.1 was used for this study (Smith, 2012). The game was accessed with Google Play for free download. SpaceTeam is a multiplayer interactive game that allows two to eight people to work as a "space team." The purpose of the game is to keep the spacecraft functioning while traveling through space. To do this, each player is provided a selection of control panels with labels and instruction on what to do with these control panels. The instructions one receives may not apply to their set of control panels, so they must repeat the instructions out loud to fellow players. They must also listen to the instructions of other players to set their control panels to the correct setting. Each level becomes more and more difficult, so cooperation and participation are key. The game was chosen as a stressor due to its social evaluative, uncontrollable characteristics, and music that have been shown to raise cortisol levels (Dickerson and Kemeny, 2004; Vijgh, Beun, Rood, & Werkhoven, 2015).

Cortisol Saliva kit: The cortisol saliva kit contained 150 Saliva Collection Aids, 150 2 mL Cryovials, 2 Cryostorage boxes, 144 1" x ¾" Cryo-Labels, and 1 Bio-shipper.

Tablets: Five Amazon Fire (5th Generation) tablets were used to both collect online survey questions as well as provide an even playing medium for the video game stressor.

Procedure

This experiment's procedure was reviewed and approved by the University of Hawai'i at Mānoa Review Board. Participants came into the lab to provide consent and answer questionnaires to get a baseline measure of their gratitude, satisfaction with life, and perceived stress levels. Once the questionnaire was completed, participants provided a saliva sample to establish their initial cortisol levels. Participants played then the multiplayer video game SpaceTeam for 20 minutes to ensure adequate cortisol reactivity (Kirschbaum, 1995).

After the 20 minutes were over, participants provided a second saliva sample so that pre-intervention cortisol reactivity could be established. Once saliva samples were obtained, subjects were told their pre-assigned group: Control or Experimental group. Both groups were assigned a writing task that was to be done every day for a total of four weeks. The experimental group was assigned a writing assignment to induce gratitude by writing down three things they were grateful for everyday, as well as a short weekly paragraph explaining the broader aspects of their life for which they were grateful. The control group was assigned to write down three small events that occurred throughout the day and a short weekly paragraph explaining the broader aspects of their life that were neutral and did not elicit any emotional response. Participants were instructed to email lists and paragraphs to the researcher every day/week with only their assigned study ID, date, and list number in the subject line.

Once the four weeks were finished, participants came into the lab and answered the questionnaires measuring post-intervention gratitude, satisfaction with life, and perceived stress levels once again. They then provided saliva samples for cortisol measurements and played the same video game for 20 minutes. Finally, after playing the video game the second saliva samples were collected to get the post-intervention cortisol reactivity measurements.

Measures

Satisfaction with Life: Life satisfaction with measured with the Satisfaction with Life Scale (Diener, Emmons, Larsen, & Griffin, 1985). Participants rated how often they felt a certain way in the past month on a 7-point Likert scale based on a prompt (e.g. So far, I have gotten the important things I want in life). There were five items ($\alpha = 0.86$) with scores ranging from 5 to 35, with 5 indicating extremely dissatisfied with life and a score of 35 indicating extremely satisfied with life.

Perceived Stress Scale: Stress levels were measured with the Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983). This is a 10-item ($\alpha = 0.77$) 5 point Likert-Scale, ranging from 0 = Never to 4 = Very Often, rating how often participants felt a certain way in the past month based on the provided prompt (e.g. How often have you felt nervous and "stressed"?). Positively stated item scores were reversed and then all scores were added together to get a final overall score. Scores ranged from 0 to 40, with a score of 0 indicating no stress and a score of 40 indicating extreme stress.

Gratitude: Gratitude was measured with The Gratitude Questionnaire (McCullough, Emmons, & Tsang, 2002). This 6-item ($\alpha = 0.78$) 7 point Likert scale asked

to what degree does the participant agree with the prompt (e.g. As I get older I find myself more able to appreciate the people, events, and situations that have been part of my life history) with a score of 1 being strongly disagree and 7 being strongly agree. Negatively stated prompts were reverse scored and all scores were summed for an overall score. Overall scores ranged from 6, extremely ungrateful, to 42, extremely grateful.

Cortisol Reactivity: Cortisol levels were tested through saliva sampling because it is easy to administer and non-invasive. Research has shown that cortisol concentration in both saliva and serum sampling show nearly identical concentrations, suggesting saliva sampling of cortisol is as valid as serum, or blood, sampling (Tunn, Mollmann, Barth, Derendorf, & Krieg, 1992). Cortisol levels were analyzed by Salimetrics Inc. Data were sent back to researchers for statistical analysis. Saliva collection kits were purchased from Salimetrics, LLC. The kit included Saliva Collection Aids, 2mL cryovials, cryostorage boxes, cryo-Labels, and a bioshipper. Testing services were provided by the Salimetrics SalivaLab in University of California, Irvine.

Results

Average perceived stress scores and gratitude scores were calculated by first reversing scoring questions and then adding scores. Average satisfaction with life was calculated by simply adding up scores. All scores were averaged out after calculating individual scores. Higher scores meant higher levels of all three measures and lower scores meant lower levels for all three measures. Pre-intervention measures are summarized in Table 1 and post-intervention measures are summarized in Table 2. Cortisol reactivity was calculated by subtracting post-stress measures from pre-stress measures. The average gratitude score in the gratitude group was 33.5 (SD = 6.56) pre-intervention and the average post-intervention gratitude score was 33.2 (SD = 6.29). The control group had an average gratitude score of 36.7 (SD = 3.15) pre-intervention and an average gratitude score of 36.1 (SD = 4.47) post-intervention. The gratitude group had an average perceived stress score of 21.9 (SD = 6.64) pre-intervention and an average perceived stress score of 19.7 (SD = 5.21) post-intervention. The control group had an average perceived stress score of 19.2 (SD = 3.73) pre-intervention and an average perceived stress score of 17.9 (SD = 3.34). The gratitude group had an average satisfaction with life score of 19.9 (SD = 6.70) pre-intervention and an average satisfaction with life score of 22.4 (SD = 6.81) post-intervention. The control group had an average satisfaction with life score of 24.8 (SD = 5.23) pre-intervention and an average satisfaction with life score of 25.2 (SD = 5.94) post-intervention. The gratitude group had an average cortisol reactivity score of –0.012 µg/dL (SD = 0.073 µg/dL) pre-intervention and an average cortisol reactivity score of –0.033 µg/dL (SD = 0.066 µg/dL) post-intervention. The control group had an average cortisol reactivity score of –0.041 µg/dL (SD = 0.050 µg/dL) pre-intervention and an average cortisol reactivity score of –0.017 µg/dL (SD = 0.0546 µg/dL) post-intervention.

Pre-intervention measures did not differ significantly for all four measures. To ensure that the control and experimental groups did not differ in pre-intervention measures, t-tests were done between groups. No measures showed any significant differences between

Table 1 Pre-intervention measures in control and experimental conditions

	GRATITUDE		CONTROL		
MEASURE	MEAN	SD	MEAN	SD	ALPHA
Gratitude	33.5	6.56	36.7	3.15	0.88
Perceived Stress	21. 9	6.64	19.2	3.73	0.81
Satisfaction with Life	19.9	6.70	24.8	5.23	0.88
Cortisol (µg/dL)	–0.0118	0.0725	–0.0413	0.0504	—

Note. SD = Standard Deviation. Alpha = Cronbach's Alpha.

Table 2 Post-intervention measures and cortisol reactivity in control and experimental groups

	GRATITUDE		CONTROL			
MEASURE	MEAN	SD	MEAN	SD	*T*-TEST	ALPHA
Gratitude	33.2	6.29	36.1	4.47	0.43	0.80
Perceived Stress	19.7	5.21	17.9	3.42	0.27	0.68
Satisfaction with Life	22.4	6.70	25.2	5.94	0.11	0.87
Cortisol (µg/dL)	–0.033	0.0655	–0.0170	0.0546	0.07	—

Note. SD = Standard Deviation. Alpha = Cronbach's Alpha. *t*-test = *t*-test between groups.

groups (gratitude $t(36) = 0.03$, p = n.s., perceived stress $t(36) = 0.06$, p = n.s., satisfaction with life $t(36) = 0.01$, p = n.s.).

T-tests were done with difference scores between pre-intervention measures and post-intervention measures on all four measures. None of the measures showed statistically significant results. Gratitude decreased slightly in both groups, but not significantly, $t(36) = 0.43$, p = n.s. Perceived stress decreased slightly in both the experimental group and control group, but again not to a significant degree, $t(36) = 0.27$, p = n.s. Satisfaction with life increased slightly more so in the gratitude intervention than the control condition, but not significantly, $t(36) = 0.11$, p = n.s. Cortisol reactivity went down, suggesting the stressor did not increase stress, but rather decreased it. Cortisol reactivity levels, which again was calculated by subtracting post-stressor levels with pre-stressor levels, decreased more so in the experimental condition when compared to the control condition, but again not significantly, $t(36) = 0.07$, p = n.s.

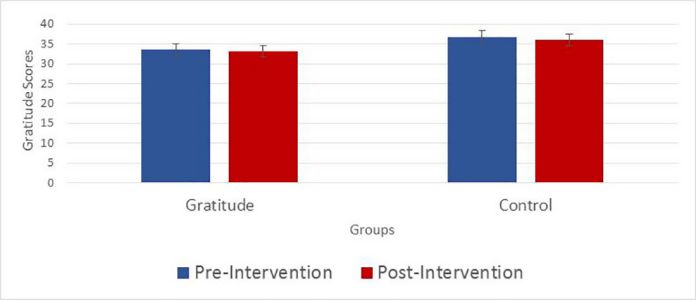

Figure 3 Mean gratitude scores pre-intervention and post-intervention in both the experimental (gratitude) and control group. Standard errors are represented in the figure by the error bars attached to each column.

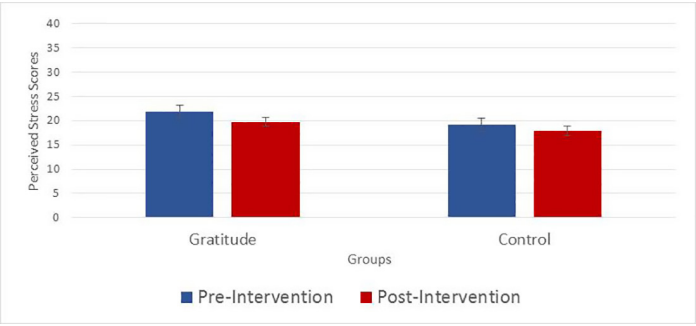

Figure 4 Mean perceived stress scores pre-intervention and post-intervention in both the experimental (gratitude) and control group. Standard errors are represented in the figure by the error bars attached to each column.

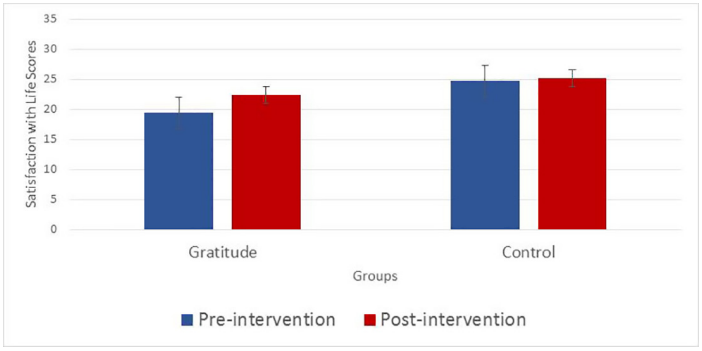

Figure 5 Mean satisfaction with life scores pre-intervention and post-intervention in both the experimental (gratitude) and control group. Standard errors are represented in the figure by the error bars attached to each column.

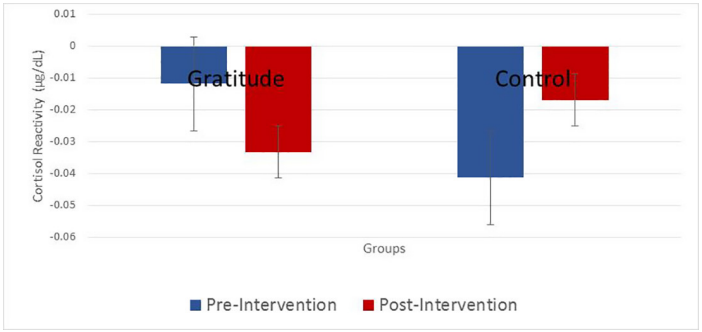

Figure 6 Mean Cortisol Reactivity pre-intervention and post-intervention in both the experimental (gratitude) and control group. Standard errors are represented in the figure by the error bars attached to each column.

Discussion

The purpose of this experiment was to determine if gratitude interventions, when compared to a matched activity, could improve satisfaction with life, gratitude, perceived stress, and cortisol reactivity scores. Previous research suggests gratitude interventions could be an effective tool to manage stress, while improving other aspects of well-being. The study used a gratitude intervention in which participants were to write down three things they were grateful for that day as well as a short weekly paragraph describing the things they were grateful in a broader sense. Participants were told to not repeat items on the list so that they may focus on smaller aspects of their day. The control group was told to simply do a list of 3 neutral events that occurred daily with a short weekly paragraph outlining broader aspects of their life. They were again told to not repeat items from previous lists. The interven-

tion did not have significant improvements in any of the measures, including cortisol.

Our data agrees with the conclusions drawn from Davis and others' (2016) findings in that gratitude interventions might only marginally improve certain aspects of an individual's well-being. They concluded that some of the benefits may come from a simple placebo affect rather than a true enhancement of their outlook on life. Sin & Lyubomirsky (2009) found that members of individualistic cultures tend to benefit most from positive psychology interventions (PPIs) when compared to those from collectivist cultures. This would partially explain the lack of response from the gratitude intervention being that a majority identified as either Asian or Native Hawaiian, both being collectivist cultures (Brightman & Subedi, 2007; Triandis, 1996).

This study had several limitations including the sample, motivation of the students, how and when the stressor was presented, and overlooking the interplay between DHEA and cortisol. The sample chosen for this experiment had relatively high baseline happiness levels. They scored high on the gratitude scale and the satisfaction of life scale and low in the perceived stress scale. Beginning with generally content people leaves less room for improvement. The sample was also somewhat homogenous in that most them were young Asian females. Even if the intervention improvement in any measure, the conclusions drawn from the experiment could only apply to a small subsection of a population. Lastly, the students chosen for the experiment were Family Resources majors, which may attract less innately competitive individuals than other college majors, although these are assumptions and are not based on data.

Another limitation with this study was motivation to do the intervention. Participation of the subjects was based on earning class credit and not by intrinsic motivation to improve their outlook on life. Those who self-selected into doing PPIs benefited most from the intervention (Sin & Lyubomirsky, 2009), so coercing participants to do the tasks for credit may have dampened the positive effects of the intervention. What is the more likely case is that the participants did the intervention with the purpose of turning in just enough to get the credit and not to actually reflect on the daily events.

The video game used as a stressor had technical issues for a majority of the participants (18 out of 28) during the first session. The game had as weak internet connection, resulting in waiting periods and some eventually having to be excused early. Also, the game itself may not have been stressful to them due to their lack of motivation to do well in the game. Third, the researcher who conducted the lab sessions might not have been very intimidating. She possessed no true power over the participants, making participants perceive less stress. Lastly, the game itself may have simply been perceived as more enjoyable than stressful, resulting in no release of cortisol.

The time of day should have been the same for all participants to administer the stressor. Research that was conducted after 12 p.m. had more consistent cortisol readings when compared to research that was conducted before 12 p.m. (Dickerson & Kemeny, 2004), suggesting cortisol is more stable in the afternoons when compared to the mornings. Due to time constraints, multiple sessions had to be done in one day, making the time of cortisol induction varied. Recent research has suggested that DHEA should be considered in ratio with cortisol when examining HPA-axis functioning (Kamin & Kertes, 2017). Although cortisol and DHEA are both secreted by the HPA-axis in response to stress, they perform largely opposing biological, neurological, and immunologic functions. For example, prolonged cortisol exposure has been linked to memory and cognitive impairments, but in rodent studies, administration of DHEA(S) offsets the neurotoxic effects of cortisol in the hippocampus, counteracting the impairing effects of cortisol on memory, and reversing weight gain induced by elevated glucocorticoids. DHEA released with cortisol may function as a stress combatant in a sense (Kamin & Kertes, 2017), making it an integral part of understanding the nuances of HPA-axis functioning.

Future research should repeat this study but focus on participants that primarily come from individualistic cultures and who are actively seeking out help for their depression and/or anxiety (Sin & Lyubomirsky, 2009). The interventions may prove stronger in this type of sample rather than the sample chosen for this study. What this study does offer is a "baseline" for future studies to compare different types of populations. These experiments were conducted on individuals with a high level of overall well-being. If results in future research show that the gratitude intervention is affective in a sample with lower levels of overall well-being, one may be able to conclude it is in fact addressing stress and other aspects of well-being, but that everyday hassles may not be as troubling as previously assumed. Also, because the intervention used in these experiments did not improve gratitude scores, the relationship between gratitude and stress and cortisol is still a possibility, but

gratitude must be induced with a different intervention. Future studies should also consider a stressor, administered at the same time of day for all participants, that is more widely accepted to test cortisol reactivity, like the Trier Social Stress Test (Kirschbaum et al., 1995; Dickerson and Kemeny, 2004), which consists of a public speaking task for a mock job interview, and an arithmetic task in front of an audience while being told they are being recorded.

Conclusion

The findings of this study exemplify the need for critical evaluations of PPIs like gratitude interventions for them to be an effective tool for managing stress and improving overall well-being. Clinical research may be the key to understanding the full potential of these types of interventions and should be the primary method of investigation. Currently the link between gratitude and physiological measures like cortisol is still not fully understood, making this type of research an important step into helping the prevention or treatment of psychological disorders like depression and anxiety. If this research is replicated in more stringent terms, meaning incorporating the suggestions made above, to no avail, it can be concluded that gratitude may simply not have any clinical value in the realm of cortisol improvement, but the current research has not completely ruled out the possibility.

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