AN ABSTRACT OF THE THESIS OF

James Spencer Hutchinson for the degree of Honors Baccalaureate of Science in Biology presented on May 24, 2012. Title: The Heart of Elevation: Investigating the Physiological and Neural Mechanisms Underlying Moral Elevation.

Abstract Approved:____

Sarina R. Saturn

Moral elevation refers to the distinct state of warmth and expansion that some individuals experience after witnessing or learning about the altruistic acts of others. Elevation is a particularly interesting positive emotion for its capacity to promote various altruistic behaviors, as well as motivate witnesses to improve their character.

The heart of this honors thesis focused on narrowing the gap of knowledge related to physiological and neural mechanisms underlying moral elevation. We hypothesized that elevation is an emotional state under the influence of the social communication system described in the polyvagal theory. We also hypothesized that prefrontal cortex activity would relate to elevation. Measures of respiratory sinus arrhythmia displayed parasympathetic influence on the heart during elevation, an indirect indication of oxytocin release. In addition, functional near infrared spectroscopy imaging of the medial prefrontal cortex revealed that blood oxygenation level-dependent signals of this brain region negatively correlated to self-reported prosocial motivation after elevation induction. Altogether, this study demonstrates the first evidence of how the body and brain are involved in the experience of moral elevation.

Keywords: elevation, physiology, prefrontal cortex, respiratory sinus arrhythmia, psychology, emotion

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The Heart of Elevation:

Investigating the Physiological and Neural Mechanisms Underlying Moral Elevation

By

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I understand that my project will become part of the permanent collection of Oregon State University, University Honors College. My signature below authorizes release of my project to any reader upon request.

J. Spencer Hutchinson, Author

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

The Heart of Elevation:

Investigating the Physiological and Neural Mechanisms Underlying Moral Elevation

Introduction

> "It is a basic fact about human beings that we sometimes help others, even strangers, at some cost or risk to ourselves. Psychology has a lot to say about this basic fact, as altruism has been a major area of research for the past thirty years. It is also a basic fact about human beings that we are easily and strongly moved by the altruism of others. Psychology has almost nothing to say about this fact, and this is an oversight that positive psychology must correct. We cannot have a full understanding of human morality until we can explain why and how human beings are so powerfully affected by the sight of a stranger helping another stranger." (Haidt, J. 2003a)

Elevation

This powerful feeling that occurs as a result of witnessing the altruism of others is called "moral elevation." The discrete emotion of elevation was first coined by Jonathan Haidt little over a decade ago (Haidt, 2000). Haidt and his collaborators have defined elevation as the warm, uplifting feeling that one experiences after witnessing unexpected and sometimes extreme acts of human benevolence, such as compassion or heroism (Algoe & Haidt, 2009; Haidt, 2003a, 2003b; Keltner & Haidt, 2003).

Before his work on elevation Jonathan Haidt spent almost a decade studying the negative emotion of disgust (Haidt, 2003a). The thorough research of Haidt and his colleagues has led to the characterization of disgust as a complex emotion designed to protect the body and "soul" from degradation (Haidt, McCauley, & Rozin, 1994; Rozin, Haidt, McCauley, 2008). Rozin et al. (2008) note nine classes that elicit disgust: food, body products, animals, sexual behaviors, contact with death or corpses, violations of the exterior envelope of the body, poor hygiene, interpersonal contamination and social disgust. In his first paper of elevation, Haidt (2000) explains that disgust elicited by objects that can potentially spread disease can be understood as an evolutionary adaptation. Disassociation from these types of disgust elicitors can possibly protect the body from harm. To explain feelings of disgust in response to social behaviors, Haidt has proposed a vertical dimension of moral repute. Drawing from the medieval *scala natura* and the higher and lower levels of Hindu reincarnation, Haidt's dimension runs from a high end of moral purity and sainthood down to lower planes of animal or subhuman status. Acts of moral corruption such as betrayal, hypocrisy and racism have been shown to elicit social disgust (Sherman & Haidt, 2011). Individuals experiencing this revulsion to moral depravity describe feeling cynical about humanity, closed off to human interaction as well as nauseous, the physiological state typically associated with all forms of disgust (Haidt, 2000; Haidt, 2003a). Those experiencing social disgust separate themselves from what appears to be a morally contaminated humanity, just how individuals separate themselves from those disgust elicitors that are viewed to be potentially contaminated with disease.

If social disgust is the negative emotion elicited by witnessing people moving down the moral hierarchy, then elevation is the opposite: a positive emotion in response to witnessing people moving up by way of admirable moral deeds (Haidt, 2000). Preliminary evidence from self-reports of elevation has illustrated the diametrically opposed features of elevation and social disgust (Algoe & Haidt, 2009; Haidt, 2003a; Haidt, et al., 2001; Landis et al., 2009). The physical feelings commonly elicited by elevation are a stark contrast to the nausea that is associated with social disgust; elevated individuals frequently describe pleasant warm or tingly sensations in their chest, a lump in the throat, tears in the eyes, and alterations in heart rate (Algoe & Haidt, 2009;

Freeman, Aquino & McFerran, 2009; Haidt, 2003a). Furthermore, while social disgust generally triggers an impulse to separate from humanity, those experiencing elevation tend to report a motivation to affiliate with others. A longing to become a better person and desiring to help others are distinct hallmarks of elevation (Algoe & Haidt, 2009; Haidt, 2000; Haidt, 2003a.)

Positive Psychology

Positive emotions, such as amusement, love, awe and now elevation, are markedly underrepresented in psychological research. Clinical psychology has been rooted in the study of mental illness and how human beings are able to endure difficult circumstances. There has been much less effort invested in understanding the emotions that people experience during pleasant or favorable circumstances. It has long been the perception in the psychological community that positive emotions have fewer applications than their negative counterparts (Seligman, 2000).

Contrary to the traditional perception, Barbara Fredrickson's (2000) hypothesized broaden-and-build model explains that the cultivation of positive emotions can be used to prevent and treat the problems associated with negative emotions. The model describes that positive emotions have an undoing effect on negative emotions. Fredrickson (2000) and other psychologists have since described the potential uses of positive emotions to improve the health and well-being of humanity (Folkman & Moskowitz, 2000; Fredrickson et al., 2000).

Elevation is a particularly interesting positive emotion for its capacity to promote various altruistic behaviors, as well as motivate witnesses to improve their character. Haidt (2000) notes that elevation's power to spread gives it the potential to improve entire communities. Researchers of elevation agree that their work has the capability to uncover applications that could potentially increase the general level of prosociality in society (Haidt, 2003a; Schnall, & Roper, 2012; Schnall, Roper, & Fessler, 2010)

Previous Research

Recently, researchers have been looking to uncover direct evidence linking elevation and increased helping behaviors. Freeman, Aquino, and McFerran (2009) elicited elevation by having participants watch clips or read about acts of compassion. The sample population was white undergraduates high in social dominance orientation, a personality trait that is typically correlated to anti-Black racism. Consistent with previous studies, participants in the elevation group were more likely to report chills and tingles, a lump in their throat, tears in their eyes, warmth in their chest, blushing, an increased heart rate, or a feeling of lightness. Relative to the control condition, the elevation condition increased participants' donations to the United Negro College Fund (UNCF), a charity for the advancement of education of Black students. This data provides indications that elevation attenuated the negative effects of those high in social dominance orientation.

Schnall, Roper and Fessler (2010) elicited elevation using a clip from an episode of "The Oprah Winfrey Show." In the clip, two generations of musicians coming from impoverished backgrounds thanked the teachers who had mentored them and kept them from a probable life of crime. In the study, participants' degree of helping behavior was measured by their willingness to volunteer for an unpaid study or complete a boring math questionnaire. Participants who had watched the elevation clip demonstrated higher levels of altruistic behavior compared to participants who watched a neutral control clip of a nature documentary or a clip of British comedy. This research provides direct evidence for the link between elevation and increased prosocial behavior. Furthermore, Schnall, Roper and Fessler (2010) noted that elevation inspired helping in spirit, not in kind. This was shown by the fact that elevated participants engaged in helping behaviors distinctly different from behaviors viewed in the elevation-eliciting clip. The significant difference in helping behavior between those having watched the elevation clip versus the comedy clip reveals that the effects of elevation cannot be attributed to a mere positive mood, supporting the hypothesis that elevation is a discrete emotional state (Algoe & Haidt, 2009; Haidt, 2003a, 2003b)

Psychophysiology

The relationship between emotional arousal and the physiological changes controlled by the autonomic nervous system (ANS) has been the focus for many theorists and studies. Changes in the autonomic nervous system are thought to prepare the body for the appropriate adaptive responses depending upon emotional experience. (Cannon, 1915; Frijda, 1986; Lang, 1985; Tooby & Cosmides, 2008). A commonly used example is how fear causes activation of the sympathetic branch of the autonomic nervous system so as to facilitate “fight or flight” response (Rodrigues et al., 2009a).

Since varying emotional experiences require distinct adaptive responses it is expected that there arise different autonomic activation. Many of those who hypothesize discrete emotional states predict these distinct emotions have specific characteristic autonomic patterning (Ekman, 1992; Tooby & Cosmides, 2008). In the field of positive psychology, Shiota et al. (2011) conducted a study that detected significant degrees of specificity in ANS responding among five positive emotions (anticipatory enthusiasm, attachment love, nurturant love, amusement, and awe). Despite their findings, Shiota and colleagues admit that there is more work to be done to fully characterize the autonomic nervous system aspects of positive emotions.

The Present Study

At present, virtually nothing is known about the autonomic nervous system aspects of elevation. Although it is a new addition to the already under researched field of positive psychology, the previously mentioned potential benefits that can be derived from elevation serve as a beckon for further research. The heart of this honors thesis focused on narrowing the gap of knowledge related to physiological and related neural characteristics underlying moral elevation.

It has been proposed that positive emotions associated with social bonding are characterized by enhanced activation of the vaso-vagal branch of the parasympathetic nervous system (Porges, 1997). Stephen Porges's polyvagal theory introduced a new perspective relating autonomic function to behavior (Porges, 1995). A component of the parasympathetic branch of the ANS, the vagus nerve is a cranial nerve that acts to innervate the viscera. The polyvagal theory emphasizes two distinct branches of the vagus nerve, the myelinated and unmyelinated vagus, which each control different adaptive behavioral strategies (Porges, 1995).

According to the polyvagal theory there are three autonomic subsystems in vertebrates: one linked to social communication, one to mobilization and the third to immobilization (Porges, 2007). The theory describes that these three subsystems function under a phylogenetic hierarchical model in which the more evolved neural subsystem inhibits the more primitive ones. In environments that are perceived to be safe the social communication system dampens the functioning of the mobilization, or active avoidance, system that controls fight-or-flight behaviors, as well as the immobilization, or passive avoidance, system that controls feigning death behaviors (Porges, 2007).

The newly evolved social communication system, or social engagement system (SES), is linked to behaviors that facilitate social interaction: facial expressions, vocalization and listening. The SES is dependent upon the myelinated vagus that promotes calm behavioral states. The myelinated vagus accomplishes this by actively inhibiting the sympathetic nervous system's influence to the heart while also reducing hypothalamic pituitary adrenal (HPA) axis activity (Porges, 2007). Porges describes the myelinated vagus as a "vagal break." By modulating visceral states the vagal brake is able to either mobilize or calm an individual very quickly. In order to support social engagement behaviors, the vagal brake is maintained or increased.

Neurons in the vagus nerve's medullary source nuclei are modulated by oxytocin (Porges, 2007). Accordingly, oxytocin has a stimulatory action on the vagus nerve (Charpak et al., 1984). Oxytocin is a nine amino acid neuropeptide synthesized in the hypothalamus. Oxytocin functions as both a hormone and neurotransmitter with well-characterized functions in reproductive tissue and the central nervous system (Carter et al., 2009). Silvers and Haidt (2008) reported that elevation caused mothers to lactate more, suggesting that elevation increased levels of oxytocin, a principle hormone in milk letdown.

Similar to the myelinated vagus, oxytocin has been shown to support prosocial behavior while also attenuating stress response from the HPA axis (Carter et al., 2009; Rodrigues et al., 2009b). In humans, intranasal administration of oxytocin increases generosity and trust (Kosfeld et al., 2005; Zak, Stanton & Ahmadi, 2007). Studies regarding the anxiolytic effects of oxytocin have demonstrated that intranasal doses of oxytocin reduce amygdala activation (Kirsch et al., 2005). Reduced amygdala activation has been linked to increased sociability and decreased social fear (Adolphs et al., 2005; Meyer-Lindenberg et al., 2005). Conversely, increased activity of the amygdala has been observed in social avoidance and phobia (Stein et al., 2002).

Another factor capable of controlling amygdala responsiveness and regulating emotions lies within the prefrontal cortex (PFC). This region of the brain is involved in planning complex cognitive behavior, personality expression, decision-making and moderation of social behavior (Yang & Raine, 2009). The PFC is theorized to have an inverse relationship with the amygdala. Studies have found that increased PFC activity is associated with decreases in left amygdala activity (Ochsner et al., 2004; Phan et al., 2005). Furthermore, studies have shown that less PFC activation leads to less inhibition of the amygdala and related negative emotional responses (Linnman et al, 2012)

As a positive emotion that is obviously associated with social bonding and prosocial behavior, we hypothesized that elevation is an emotional state under the influence of the social communication system described in the polyvagal theory. Thus, we expected control of the myelinated vagus to increase with the induction of elevation, which would also indirectly indicate oxytocin release. Furthermore, elevation induction should result in activation of subregions of the prefrontal cortex implying further inhibition of the amygdala. To test these hypotheses we utilized physiological and neural measures recorded during either an elevation-inducing condition or a humor-inducing control condition.

Method

Participants

Participants were 46 undergraduates enrolled in Psychology courses at Oregon State University. Mean age was 20.87 years (*SD* = 3.43), 57% of participants were female and 43% were male. Participants were recruited for this study using the university's online Psychology Experiment Sign-Up System that is available to all students enrolled in psychology courses at Oregon State University. Participants received three hours of extra credit for their participation. Screening criteria ensured that all participants were at least 18 years old and that all individuals with a cardiac pacemaker were excluded from the study since this device interferes with collection of the physiological data. This study was approved by Oregon State University's Institutional Review Board.

Materials

Physiological recording used a BIOPAC MP150 hardware system (Biopac Systems Inc., Santa Barbara, CA). Continuous ANS data was recorded using Biopac's AcqKnowledge software throughout the laboratory session. All data was screened visually prior to further analysis in order to remove error and artifact (movement, sneezing, coughing, sensor displacement, and so forth)

Respiratory sinus arrhythmia (RSA, in milliseconds$(ms)^2$) is a naturally occurring rhythm in the heart rate pattern at approximately the frequency of spontaneous breathing. This variability increases with greater vagal parasympathetic influence on the heart. In this study, RSA was derived from Cardiac Interbeat Interval (IBI).

Cardiac Interbeat Interval (IBI, in ms) was measured using electrocardiography (ECG). A three-lead configuration was used to collect the ECG data with disposable electrodes on the left rib cage and right clavicle, and the ground on the right rib cage. Signals were amplified using Mindware, Inc.'s cardiography unit of the BIOPAC MP150. CardioEdit software (Brain-Body Center, University of Illinois at Chicago) was used to fix or correct problems from the ECG extraction, such as a missed heartbeat or misinterpretation of peaks. Only four data files needed editing and of these no file required editing of more than 15% total data points. Three of the four needed data files needed five or less data point corrections.

The data was then divided into 30-second windows with CardioBatch software (Brain-Body Center, University of Illinois at Chicago), which then calculated of IBI of each fragment. CardioBatch defines IBI as the time elapsed in milliseconds between R-peaks of the ECG signal, and averages these R-peaks within the fragment. Maximum heart rate was set at 180 beats/min. and minimum heart rate at 40 beats/min.

RSA was derived from the IBI series over the course of each time fragment using CardioBatch analysis software. A built in program packaged with CardioBatch calculated RSA from the IBI series based on a preprogrammed RSA adult filter. Once calculated RSA offered an approximation of the extent of parasympathetic influence on the heart.

The PFC of each participant was monitored using a continuous wave functional near-infrared spectroscopy (fNIR) system. The system was composed of three components: a flexible headpiece (sensor pad) that holds light sources and detectors, a control box for hardware management and a computer that ran the data acquisition (see Figure 1).

The sensor had a temporal resolution of 500 milliseconds per scan with 2.5 cm source-detector separation allowing for approximately 1.25cm penetration depth. The light emitting diodes (LED) were activated in turn one light source at a time and the four surrounding photodetectors around the active source were sampled. The positioning of light source and detectors on the sensor pad yielded a total of 16 active optodes (channels). COBI Studio software (Drexel University) was used for data acquisition and visualization.

Changes in light absorption, as measured by fNIR at each of the two wavelengths (730 nm and 850 nm), were used to calculate relative changes of HbO2 versus time. The method relied on the principle that near infrared light is emitted from the light source and travels through the tissue, and undergoes multiple scattering and partial absorption. Absorption occurs within hemoglobin and water, and the scattering occurs from cell membranes. The optodes sense hemodynamic variation that presents real-time changes of blood flow and oxygen levels associated to prefrontal cortex activity.

Figure 1. fNIR sensor

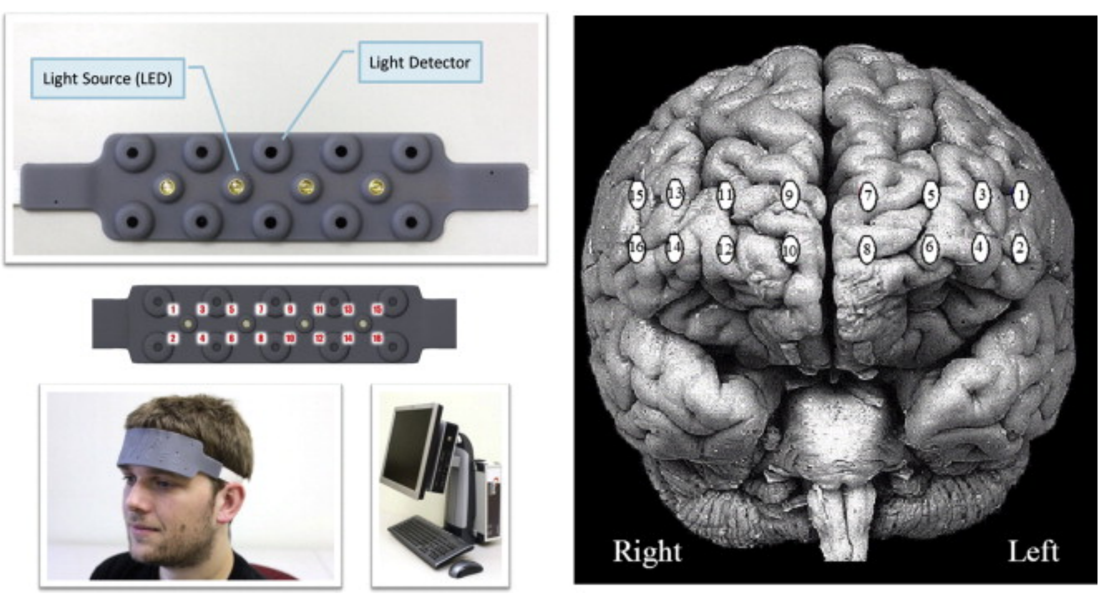


Fig. 1. fNIR sensor with 4 light sources and 10 detectors (left, top) and 16 optodes (channel) measurement locations registered on sensor (left, middle) and on brain surface image (right). fNIR sensor positioned on participants' head (left, bottom) and the fNIR Device model 1000 (bottom, middle).

(Ayaz et al., 2012)

All measures were collected throughout the laboratory session. Mean values of the physiological and neutral measures were calculated for each of the discrete periods of interest chosen for analysis: the baseline period, consisting of the measures taken during the two minutes before the start of the emotion-induction video, and the induced-emotion epoch, consisting of measures from two to nine minutes into the video (seven-minute segment).

Participants' response data was recorded using the laboratory program E-Prime 2.0 (Psychology Software Tools, Inc., Sharpsburg, PA). The laboratory session began with a baseline emotion self-report. Next participants watched video clips to induce either elevation in the experimental group or mirth in the control group followed by a self-report survey about the emotions elicited by the videos.

A video clip from "The Oprah Winfrey Show," previously used to induce elevation (Schnall & Roper, 2012; Schnall et al., 2010; Silvers & Haidt, 2008), was used in this study. The second portion of the experimental group video included a clip from Entertainment and Sports Programming Network describing how members of the opposing team assisted a softball player in scoring a home run when an injury prevented her from running the bases on her own.

The video used for the mirth control, similar to that incorporated in other elevation studies (Schnall et al., 2010; Silvers & Haidt, 2008), included a clip of comical voices dubbed over animal interactions shown in a British Broadcasting Corporation Nature documentary as well as a clip from College Humor Media entitled, "The Problem with Jeggings."

Procedure

Upon arrival at the laboratory participants completed informed consent procedures. The participants were then led to a private room where sensors for physiological measurement were attached. Tested individually, participants were randomly assigned to view the elevation-inducing clip or the humor-inducing control clip. After participants completed the script, they were unhooked from the physiological monitoring equipment, debriefed, and allowed to leave the laboratory.

Results

Manipulation Check

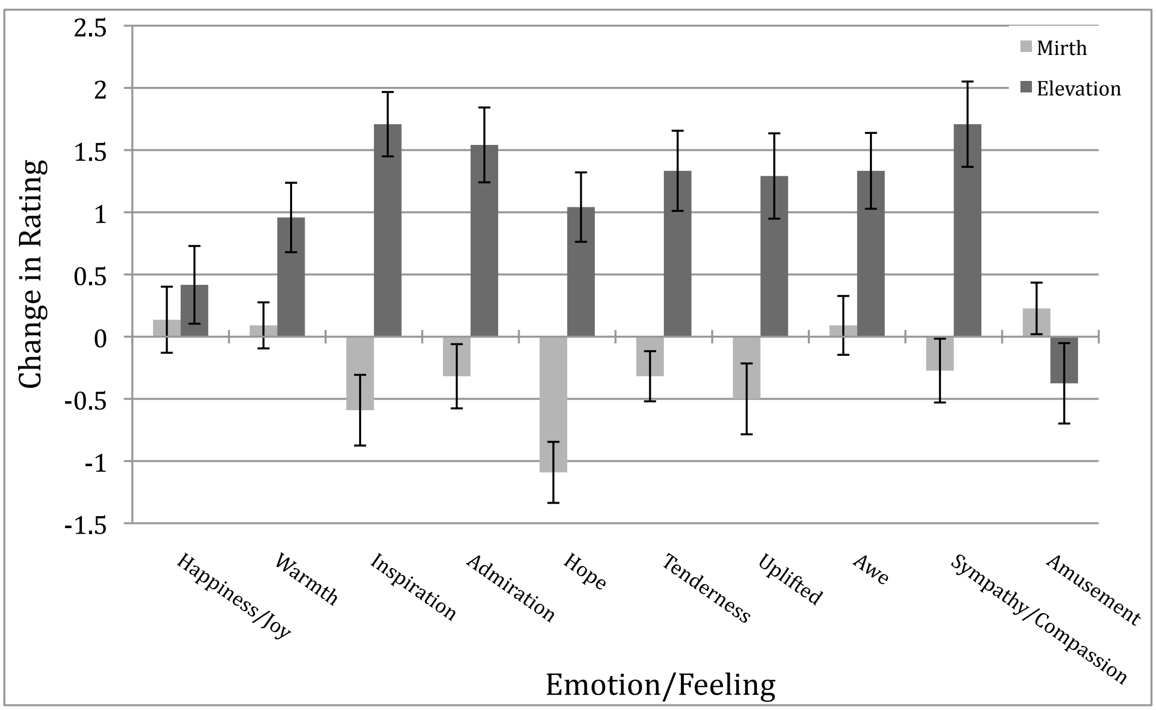
Figure 2 below illustrates the results of paired sample t-tests that were used to test for significant changes in emotional ratings between the baseline and the emotion-induction conditions. Feelings of warmth [$t(23) = 3.44$, $p = .0023$], inspiration [$t(23) = 6.60$, $p < .0001$], admiration [$t(23) = 5.12$, $p < .0001$], hope [$t(23) = 3.73$, $p = .0011$], tenderness [$t(23) = 4.14$, $p = .0004$], uplifted-ness [$t(23) = 3.77$, $p = .0001$], awe [$t(23) = 4.37$, $p = .0002$] and sympathy/compassion [$t(23) = 4.98$, $p < .0001$] all increased significantly as a result of induced elevation but not induced mirth (see Table 1). Neither group of participants reported statistically significant increases in happiness as a result of the emotion-induction conditions. Participants in the mirth condition reported increased amusement, although not statistically significant, $t(21) = 1.10$, $p = .2855$.

Table 1.
Change in Emotional Ratings between Baseline and Induced Condition

	Emotion Condition	
Emotion/Feeling	**Elevation**	**Mirth**
Happiness/Joy	0.4167	0.1364
Warmth	0.9583**	0.0909
Inspiration	1.7083**	-0.5909*
Admiration	1.5417**	-0.3182
Hope	1.0417**	-1.0909**
Tenderness	1.3333**	-0.3182
Uplifted	1.2917**	-0.5000
Awe	1.3333**	0.0909
Sympathy/Compassion	1.7083**	-0.2727
Amusement	-0.375	0.2273

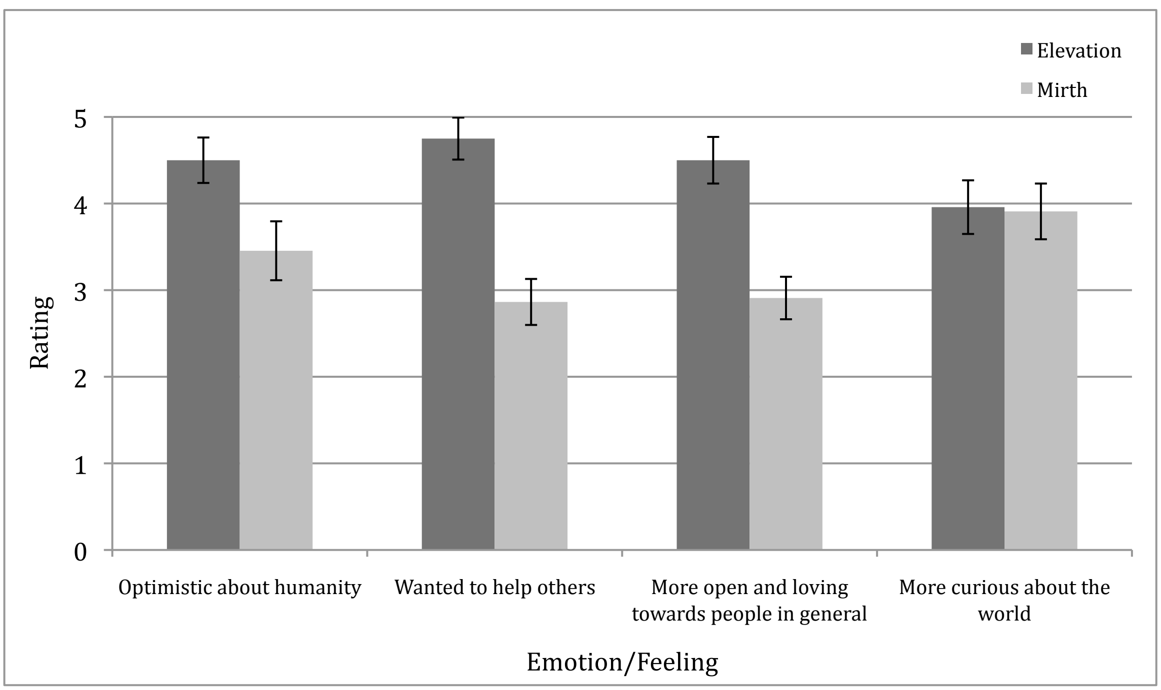
Note. * $p<0.05$ ** $p<.01$

Figure 2. Change in Emotional Ratings between Baseline and Induced Condition



Note. Error bars indicate standard errors, The independence sample t-tests results for the mean emotional ratings of participants after their designated emotion-induction condition can be viewed in Figure 3. In comparison to the mirth condition, participants exposed to the elevation clip reported significantly higher levels of feelings typically associated with induced elevation: feeling optimistic about humanity [$t(44) = 2.46$, $p = .0018$], wanting to help others [$t(44) = 5.25$, $p < .0001$] and being more open and loving towards people in general [$t(44) = 4.43$, $p < .0001$]. This data is consistent with previous studies that have demonstrated that the effects of elevation cannot be attributed to a mere positive mood (Schnall, Roper, & Fessler, 2010)

Figure 3. Emotional Ratings after Video Induction



Note. Error bars indicate standard errors

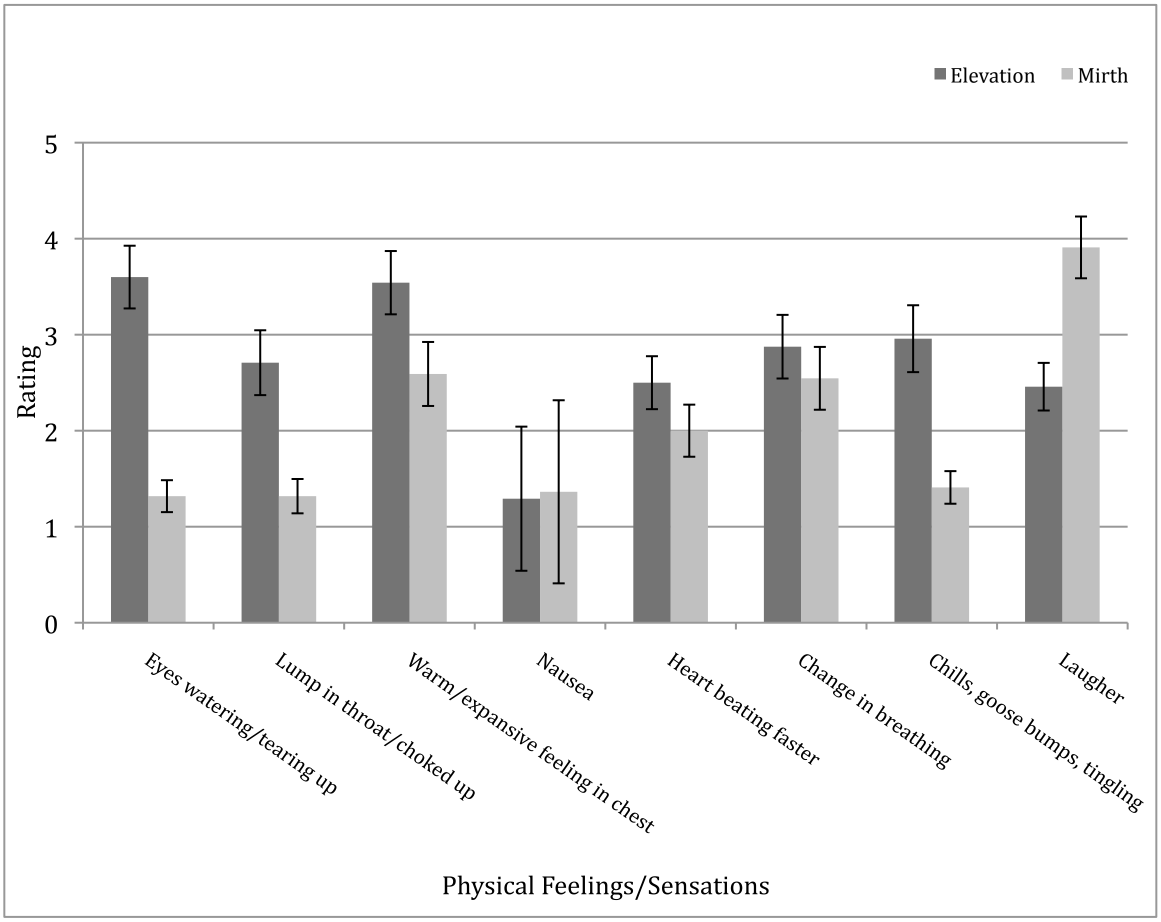
Table 2.
Difference in Emotional Ratings between Emotion-induction Conditions

Emotion/Feeling	Difference (Elevation - Mirth)
Optimistic about humanity	1.0455*
Wanted to help others	1.8864**
More open and loving towards people in general	1.5909**
More curious about the world	0.0492

Note. * p<0.05 ** p<.01

The mean self-report ratings of the physical feelings or sensations felt during the two emotion-induction conditions can be seen in Figure 4 below. Once again, independence sample t-tests showed that participants who were assigned to the elevation condition reported higher ratings for sensations typically associated with elevation induction relative to those in the mirth condition: eyes watering or tearing up [$t(35.34) = 6.23$, $p < .0001$], feeling a lump in the throat or choke up [$t(34.72) = 3.64$, $p = .0009$], a warm or expansive feeling in the chest [$t(44) = 2.03$, $p = .0489$] as well as chills, goose bumps or tingling on the skin [$t(33.18) = 4.00$, $p = .0003$] were all significantly higher (see Table 3). As expected, the mean rating for laughter was significantly higher in the mirth ($M = 3.9091$, $SD = 1.509$) than in the elevation ($M = 2.4583$, $SD = 1.2151$) condition; $t(44) = -3.61$, $p = .0008$. Reports of nausea, the sensation typically linked with disgust, were low in both the elevation ($M = 1.2917$, $SD = 0.7506$) and mirth ($M = 1.3636$, $SD = 0.9535$) conditions and showed no statistically significant difference; $t(44) = -0.29$, $p = .7765$.

Figure 4. Physical Feeling Ratings after Video Induction



Note. Error bars indicate standard errors

Table 3.
Difference in Physical Feeling/Sensation Ratings between Emotion-induction Conditions

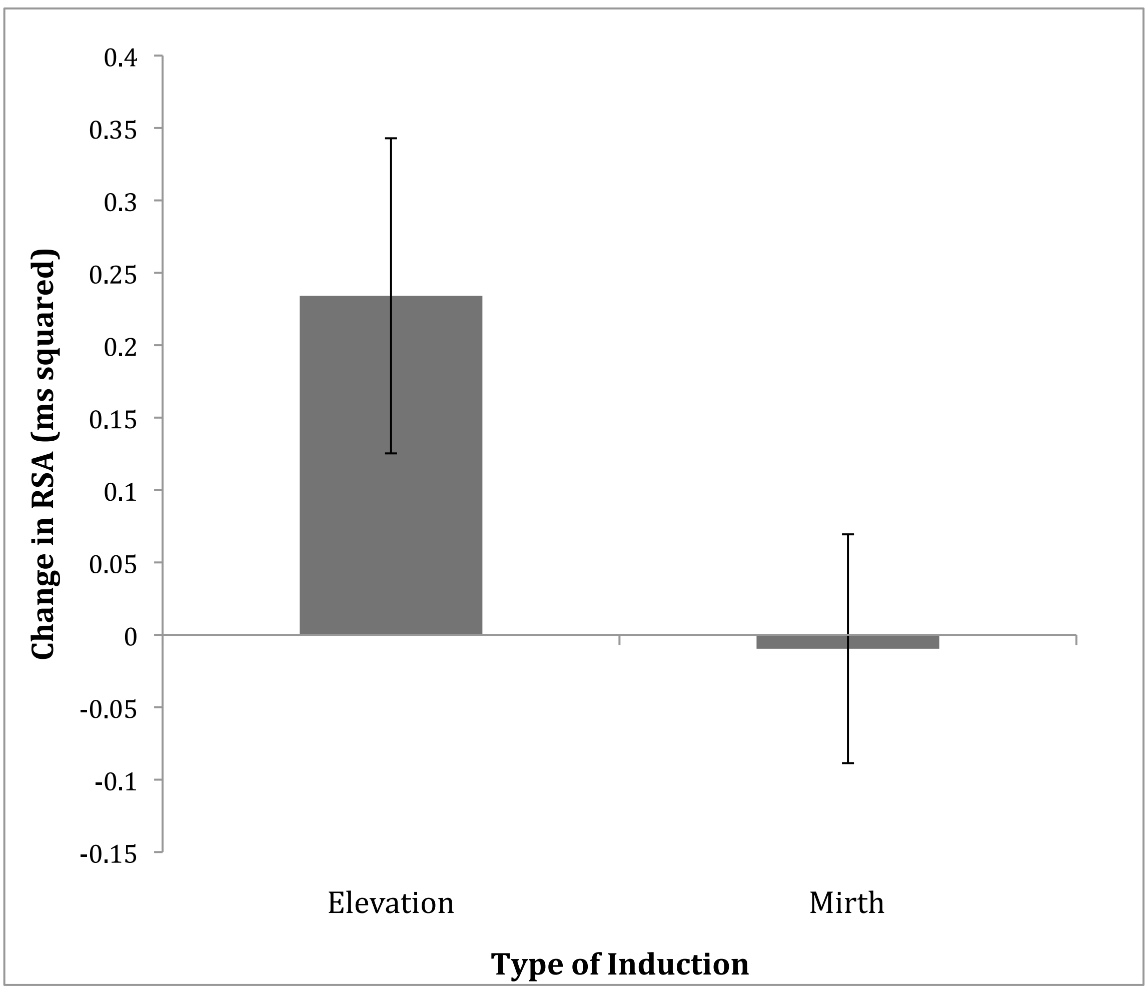
Physical Feeling/Sensation	**Difference (Elevation - Mirth)**
Eyes watering/tearing up	2.2818**
Lump in throat/choked up	1.3902**
Warm/expansive feeling in chest	0.9508*
Nausea	-0.072
Heart beating faster	0.5000
Change in breathing	0.3295
Chills, goose bumps, tingling on skin	1.5492**
Laugher	-1.4508**

Note. * $p<0.05$ ** $p<.01$

Hypothesis Testing

Paired t-tests were used to test for significant increases in RSA between the baseline and assigned emotion-induction conditions (see Figure 5). The elevation condition had a mean RSA increase of 0.2341, $t(23) = 2.15$, $p = .0409$, while the mirth control condition showed a mean increase in RSA of –0.0096, $t(21) = –0.12$, $p = .9042$. There was no significant difference in the mean baseline RSA between the elevation (M = 6.5163, SD = 1.0179) and mirth (M = 7.0592, SD = 1.3546) conditions, $t(44) = -1.64$, p = .1069.

Figure 5. Change in RSA between Baseline and Induced Condition



Note. Error bars indicate standard errors

Table 4 and 5 below illustrates the results of paired sample t-tests of the fNIR data that were used to test for significant changes in oxygenation in the prefrontal cortex between the baseline and the emotion-induction conditions. As can be seen below, emotion-induction conditions had few statistically significant increases in PFC oxygenation. Analysis of the bilateral sets of fNIR data for the elevation condition trended towards significant increasing in PFC oxygenation (see Table 4). The right region of the PFC showed a significant increase in oxygenation as a result of the induced mirth condition (see Table 5).

Table 4.
Change in Oxygenation between Baseline and Elevation Induction

Region of Prefrontal Cortex	Mean	STDV	SE	t	df	sig.
Left (optode 6,8)	1.0572	2.2594	0.5649	1.87	15	0.0809
Medial (optode 7,8,9,10)	0.823	3.5069	1.0124	0.81	11	0.4335
Right (optode 10, 12)	0.7834	2.2049	0.5893	1.33	13	0.2066
Bilateral (optode 6,8,10,12)	2.3904	3.7868	1.0932	2.19	11	0.0513

Table 5.
Change in Oxygenation between Baseline and Mirth Induction

Region of Prefrontal Cortex	Mean	STDV	SE	t	df	sig.
Left (optode 6,8)	0.988	2.7075	0.7816	1.26	11	0.2323
Medial (optode 7,8,9,10)	2.020	4.7390	1.4986	1.35	9	0.2106
Right (optode 10, 12)	1.5962	2.3001	0.6147	2.60	13	**0.0221**
Bilateral (optode 6,8,10,12)	2.4408	4.995	1.4419	1.69	11	0.1186

Table 6 and 7 illustrate the correlation between the emotional rating and the fNIR changes in oxygenation in the medial prefrontal cortex. There were statistically significant correlations related to ratings of wanting to help others [p = 0.0575], being more open and loving towards people in general [p = .00400] and being more curious about the world [p = 0.0796].

Table 6.
Correlations between Emotion Ratings and fNIR Changes in Elevation Condition

Emotion/Feeling	**Difference fNIR (Medial)**
Optimistic about humanity	-0.10436
Wanted to help others	-0.56138*
More open & loving towards people in general	-0.59796**
More curious about the world	-0.52505*

* p<0.10 ** p<.05

Table 7.
Correlations between Emotion Ratings and fNIR Changes in Mirth Condition

Emotion/Feeling	**Difference fNIR (Medial)**
Optimistic about humanity	0.49589
Wanted to help others	0.37258
More open & loving towards people in general	0.33541
More curious about the world	0.48998

* p<0.10 ** p<.05

Discussion

General Discussion

From the self-report data it appears that the emotion-induction conditions were successful. The elevation condition resulted in statistically significant ratings for emotions and physical sensations previously associated with elevation and witnessing acts of moral benevolence (Algoe & Haidt, 2009; Haidt, 2003a, 2003b; Keltner & Haidt, 2003). As expected, participants reported high levels of amusement and laughter in the mirth condition.

In terms of physiological activity, the current study offers evidence of specific autonomic nervous system responding associated with the elevation. The elevation condition generated statistically significant increases in RSA. There was no significant statistical difference in the mean baseline RSA values between the elevation and mirth conditions. This reduces the potential argument that regression toward the mean resulted in the different in RSA values. Nevertheless, regression toward the mean still must be taken into account as a potential factor in the variability of the RSA data.

In this research, RSA acted as a continuous measure of the functional influence that the myelinated vagus has on the heart (Porges, 1995). It has been argued that only the myelinated pathway is capable of the instantaneous changes characterized by RSA, as changes in the control of the myelinated vagus can rapidly inhibit or disinhibit vagal tone (Porges 2007). Thus, the increases in RSA observed during the emotion-induction condition reveals greater vagal parasympathetic influence on the heart correlated with elevation. This increase in the influence of the myelinated vagus on the heart indirectly indicates the release of oxytocin in the body (Porges, 2007). Overall, the increased activity of myelinated vagus, with assumed release of oxytocin, seems to occur in order to facilitate the prosocial behavior that characterizes moral elevation.

Despite this statically significant increase in RSA in the elevation condition, it is difficult to formulate concrete conclusions about the autonomic nervous system functioning as it relates to induced elevation. In the study only, one physiological variable was analyzed in order to evaluate the action of the ANS. Additional studies of the physiological activity of moral elevation should utilize more ANS variables. For instance, Shiota et al. (2011) utilized four additional measures (Interbeat Interval, Pre-Ejection Period, Skin Conductance Responses, and Respiration Rate) when examining the ANS responding of discrete positive emotions. Ultimately, analysis of additional physiological variables will yield a more comprehensive profile of the ANS activity underlying elevation.

On the subject of additional measures, future studies should examine the specific role of oxytocin in elevation. This study could only assume that there was release of oxytocin based on the relationship between the vagus nerve and oxytocin. Direct measures of oxytocin concentrations need be examined, as well as genetic and sex variations of oxytocin receptors (Rodrigues et al., 2009b).

In terms of neural activity, the fNIR data collected displayed that mPFC activity was negatively correlated with prosocial motivation. This suggests that less PFC inhibition of emotional circuitry (Rodrigues, et al., 2009a) may allow the experience of elevation to wash over witnesses, thereby allowing the brain and body to process this emotional state. Unfortunately, corrupted data and faulty sensor placement nullified approximately half of the fNIR recordings that were taken over the course of this study. Large sample sizes in the future may produce more robust data on the relationship between PFC activation and emotional induction of elevation.

A great deal more work is needed to fully characterize the ANS and the neural processes involved with elevation. Nevertheless, these data does add to the growing body of research demonstrating that positive emotion is not a single-dimensional experience (Shiota et al., 2011)

Future Implications

Prior research has suggested the underlying importance of research involving elevation: it's capacity to promote various altruistic behaviors and motivate witnesses to improve their character. Future research regarding psychological and neural characterization and stimulation of elevation may generate useful applications of this positive emotion. Researchers have already pointed to potentials in elevation stimulation to increase the general level of prosociality in society (Haidt, 2003a; Schnall, & Roper, 2012; Schnall, Roper, & Fessler, 2010). Further cultivation of the social and prosocial emotions elicited by elevation may be used to clinically to prevent and treat the problems associated with negative emotions, such as social anxiety and phobias (Fredrickson, 2000). Overall, efforts to promote and publicize moral elevation may have widespread and even cost-effective results (Haidt, 2000)

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APPENDIX A

Baseline emotion self-report

RIGHT NOW, how much are you feeling the following emotions:

0 – not at all 1 2 3 4 5 – very intensely

Happiness/Joy
Warmth
Inspiration
Admiration
Hope
Tenderness
Uplifted
Awe
Sympathy/compassion
Amusement

APPENDIX B

Emotion self-report after video

The following questions are about the video you just watched:

On the scale provided, please choose the number which best represents the extent to which you experienced each of the following **emotions/feelings** during the video. Please be sure to tell us what you really felt at the moment, not what you think people would normally feel.

0 – not at all 1 2 3 4 5 – very intensely

I felt happiness/joy
I felt warmth
I felt inspiration
I felt admiration
I felt hope
I felt tenderness
I felt uplifted
I felt awe
I felt sympathy/compassion
I felt amusement

I felt optimistic about humanity
I felt I wanted to help others
I felt more open and loving towards people in general
I felt more curious about the world

On the scale provided, please choose the number which best represents the extent to which you experienced each of the following **physical feelings/sensations** during the video.

0 – not at all 1 2 3 4 5 – very intensely

Eyes watering/tearing up
Lump in throat/choked up
Warm or expansive feeling in chest
Nausea
Heart beating faster
Change in breathing
Chills, goose bumps, or tingling on skin
Laugher