THE ROLE OF POSITIVE EMOTION ELICITING ACTIVITIES AT PROMOTING PHYSIOLOGICAL RECOVERY FROM SADNESS

by

Melissa Soenke

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

2014

THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

As members of the Dissertation Committee, we certify that we have read the dissertation prepared by Melissa Soenke, titled *The role of positive emotion eliciting activities at promoting physiological recovery from sadness* and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

____ Date: (June 4, 2014)
Jeff Greenberg

____ Date: (June 4, 2014)
John J.B. Allen

____ Date: (June 4, 2014)
Matthias R. Mehl

____ Date: (June 4, 2014)
Mary-Frances O'Connor

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copies of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

____ Date: (June 4, 2014)
Dissertation Director: Jeff Greenberg

STATEMENT BY AUTHOR

SIGNED: Melissa Soenke

Table of Contents

List of Figures

Abstract

The current study investigated whether positive emotion eliciting activities facilitate the physiological, as well as subjective emotional, recovery from feelings of sadness and grief. Results indicated that participants who read a funny or neutral article after writing about the death of someone close had greater decreases in sadness and increases in positive emotion than participants who read an article about coping with grief. The funny and neutral articles were also associated with greater decreases in corrugator supercilii muscle activity. Positive emotion eliciting activities had no effect on zygomaticus major and orbicularis oculi muscle activity, heart rate, or respiratory sinus arrhythmia.

Introduction

Over the course of the last decade, a great deal has changed in the literature on coping and the ways in which we conceptualize successful coping. Many of the longstanding theories about how to properly grieve and cope have come under fire as new evidence for the importance of positive emotion in the coping process comes to light. Despite changes taking place within the psychological literature, traditional models of coping continue to hold wide popularity among the general public and maintain their positions as the most socially acceptable ways of dealing with negative life events (Lidstrøm, 2002).

When describing historic perspectives on coping, Freud’s *Mourning and Melancholia* (1917/1957) is often referred to as the source of modern perceptions on coping with grief. According to Freud (1917/1957), normal mourning involves a system of reality testing in which the individual eventually breaks his or her connection from the object of loss. This perspective emphasizes the importance of experiencing grief and related affect as part of the coping process and views the absence of this grief as indicative of an absence of attachment (Raphael, 1983), an immaturity or weakness on the part of the individual experiencing loss (Deutsch, 1937), or a repression of the loss (Sanders, 1993). Freud’s prescriptions for successful coping, come to be known as the “grief work” perspective, reflect deeply imbedded Western cultural traditions.

More recent challenges to the grief work model have come from theories about positive emotion (Fredrickson, 1998, 2001) and models of resiliency (Mancini & Bonanno, 2009; Tugade & Fredrickson, 2004) which suggest that the experience of positive emotion, rather than grief is the critical element for recovery from negative life events. Positive emotions are thought to facilitate recovery from negative life events by broadening people’s attention (Fredrickson & Branigan, 2005), inducing more creative thinking (Isen, Daubman, & Nowicki, 1987) and contributing to a broad minded coping style (Fredrickson & Joiner, 2002). Further, positive emotions have been shown to actually counteract or "undo" the cognitive (Falkenstern, Schiffrin, Nelson, Ford, & Keyser, 2009) and physiological (Fredrickson & Levenson, 1998) effects of negative emotions.

When Might Positive Emotion Coping be Inappropriate?

If, as the recent literature presupposes, there are strong benefits to using positive emotions in coping with negative life events, this raises the question: why don't more people use these strategies? Lidstrøm (2002) reminds us that scientific changes do not occur overnight and historic models of coping maintain popularity among not only the general population, but clinicians and practitioners as well. Are proponents of grief work simply stuck in their misguided ways, incapable of jumping aboard the more current and correct positive emotion coping movement? Perhaps not. The experience and expression of positive emotion in the context of certain traumatic events is not always adaptive and associated with recovery. When inappropriate emotion is consistently experienced or expressed in a given context it becomes dysfunctional, and actually impairs social functioning (Bananno et al. 2007). Engaging in positive activities, particularly social activities, immediately after experiencing the death of someone close is rated as less socially appropriate compared to more traditional grief work type activities (Soenke, Greenberg, & O'Connor, 2014). When an individual violates social norms or expectations, guilt is not an uncommon response (Mikulincer & Florian, 1997). Soenke, Greenberg & O'Connor (2014) conducted three studies investigating people's interest in and the effectiveness of using positive emotion eliciting activities for coping with experiences of sadness. Results for these studies indicated that although positive emotions appear to alleviate feelings of sadness, people report reluctance to engage in these activities, compared to other types of coping activities, and that this reluctance is mediated by anticipated feelings of guilt.

The Present Study

These initial studies measured participants' subjective emotional response using self-report questionnaires to measure the effectiveness of using positive emotion eliciting activities to facilitate recovery from sadness. Results indicated that engaging in positive emotion eliciting activities following writing about the death of someone close decreased feelings of sadness and guilt and increased positive emotion. As a follow up, the current study investigates whether positive emotion eliciting activities facilitate the physiological, in addition to the subjective, recovery from feelings of sadness and grief.

Additionally, these initial studies focused on the role that concerns about feeling guilty play in choosing to engage in positive emotion eliciting activities after experiencing a sad event. But there are important individual difference variables that may be related to whether an individual chooses a positive emotion eliciting activity to cope with an experience of sadness, and whether or not this coping strategy is effective. One potential individual difference variable, shown to play an important role in emotion regulation and coping is cardiac vagal control. Cardiac vagal control is associated with emotion regulation and measured using respiratory sinus arrhythmia. As a trait variable, high levels of vagal control are associated with more effective emotion regulation (Souza et al., 2007), and as a state variable changes in RSA and vagal control are associated with the active regulation of emotion (Austin et al., 2007).

The present study was conducted with two goals in mind: 1) to investigate whether positive emotion eliciting activities produce any changes in physiological recovery from experiences of sadness using indices of both cardiovascular response and changes in facial muscle activation, and 2) to investigate the influence of trait levels of vagal control on the effectiveness of positive emotion eliciting activities for coping with sadness.

Physiological Recovery from Sadness

Positive emotions have been shown to counteract the physiological effects of negative emotions, particularly fear and anxiety (Fredrickson & Levenson, 1998). Fredrickson and Levenson (1998) showed a group of female participants a fear-eliciting film followed by a film that elicited either contentment, amusement, neutrality, or sadness and measured cardiovascular response. Results showed that participants displayed an increase in cardiovascular activity (heart rate, heart period, pulse transmission time to ear, pulse transmission time to finger, and finger pulse amplitude) in response to the fear-inducing film. Participants who viewed the contentment and amusement films recovered significantly more quickly to baseline levels of cardiovascular activity than participants who watched the neutral or sad films (Fredrickson & Levenson, 1998). Fredrickson, Mancuso, Branigan, and Tugade (2000) replicated these results in broader samples including men and women, and African Americans. They had participants plan to give a speech under a considerable time constraint, causing participants to experience anxiety, and then had them watch a film eliciting contentment, amusement, neutrality, or sadness. Similar to Fredrickson and Levenson (1998), participants who watched the contentment and amusement films recovered more quickly to baseline levels of cardiovascular activity than participants who watched the neutral or sad films. These results suggest that positive emotions may be beneficial at a physiological as well as psychological level in recovering from negative life experiences characterized by fear, but there is no evidence in the literature indicating whether this recovery occurs for experiences of sadness.

Similarly, the experience of positive emotions has come to be a central trait of individuals characterized as *resilient*. Tugade and Fredrickson (2004) had participants engage in a negative emotion eliciting activity, preparing a speech, and found that more resilient individuals (measured using the Ego-Resiliency Scale; Block & Kreman, 1996) reported more positive mood. This experience of positive emotion during the negatively valenced task mediated the relationship between resilience and cardiovascular reactivity, with more resilient individuals experiencing greater positive emotion, and showing a faster cardiovascular recovery to baseline (Tugade & Fredrickson, 2004). These results indicate a relationship between trait resiliency, positive emotions, and physiological recovery from negative life events. This study also represents one of the few studies of active coping in the lab; however, because resiliency is an individual difference variable it is limited in its ability to speak about cause and doesn't inform on how positive emotions work in the coping process for people who aren't resilient.

Souza and colleagues (2007) had participants engage in an acute stress task similar to that used by Tugade and Fredrickson (2004). They found that participants with high levels of trait vagal control or those high in resiliency had a more rapid cardiovascular recovery from the stressful task. Results also indicated a significant interaction between trait vagal control and resiliency with participants high in both trait vagal control and resiliency recovering most quickly from the stressful task. Interestingly, in this study, the correlation between resiliency and trait vagal control was not significant.

Currently, research indicates that the experience of positive emotions facilitates physiological recovery from anxiety (Fredrickson & Levenson, 1998), but there is no existing data examining this relationship in sadness. This may be in large part due to differences in the physiological profiles of anxiety as compared to sadness. While anxiety provides a readily observable change in physiological arousal, and can be easily measured by electrocardiography (ECG), the physiological profile for sadness varies between studies and can be difficult to distinguish from neutral states (Kreibig, Wilhelm, Roth, & Gross, 2007).

In order to measure physiological arousal and recovery we used ECG to collect heart rate (HR) and respiratory sinus arrhythmia (RSA) data. HR, measured in beats per minute, is often used in studying emotion related phenomena, as changes in acceleration or deceleration are often observed in response to emotional stimuli (Bradley & Lang, 2007). For example, heart rate accelerates when people imagine themselves in an emotional situation compared to a neutral one (Bradley & Lang, 2007). Interestingly, Brosschot and Thayer (2003) found that this increase in heart rate lasts longer for negative emotions than for positive emotions. For this study, we expected to see accelerated HR among participants who wrote about a sad experience, but not a neutral experience. We predicted that among participants in the sad condition, this elevated HR would return to baseline most quickly for the participants who engaged in a positive emotion eliciting activity.

While ECG is effective at measuring general arousal, facial electromyography (EMG) has proven more reliable at distinguishing between specific emotions. Studies reliably find the experience of negative emotion to be associated with increased activity in the corrugator supercilii muscle region, while positive emotion is associated with increased activity in the zygomaticus major region (Brown & Schwartz, 1980). The level of corrugator supercilii activity can be used to differentiate sadness from other negative emotions like fear and anger. Although fear and anger show some corrugator supercilii activity, this is significantly higher for sadness, and significantly lower for positive emotions (Brown & Schwartz, 1980). EMG can also distinguish between indices of positive affect and Duchenne smiles, which have come to represent a more genuine index of positive emotion (Ekman, Davidson, & Friesen, 1980). In EMG, Duchenne smiles are associated with increased activity in the orbicularis oculi muscle region. In addition to its specificity, EMG has been shown to especially sensitive, detecting unconscious facial expression of emotion in response to stimuli presented outside of conscious awareness. Dimberg, Thunberg, and Elmehed (2000) found that participants responded with EMG activity in regions that mimicked the facial expressions of subliminally presented emotional faces. Facial EMG has also been used successfully to study online emotion regulation. In a study of reappraisal, Ray, McRae, Ochsner, and Gross (2010) replicated self-report findings using facial EMG. They found that, just as reappraisal in response to negative images decreases self-reported negative affect, it also decreases activity in the corrugator supercilii muscle region. The proposed studies will utilize both ECG and EMG to investigate whether positive emotion eliciting activities produce changes in people's physiological, as well as self-reported, experience of sadness.

Vagal Control

Initial studies indicate that concerns about feeling guilty are related to a reluctance to engage in positive emotion eliciting activities after experiencing a sad event. But there may be individual difference variables, in addition to these situational ones, that contribute to who chooses to use positive emotion eliciting activities during the coping process. These variables may determine which individuals are best able to effectively use these activities. One individual difference variable that has been shown to be especially important in effectively regulating one's emotions is cardiac vagal control. As an individual difference variable, high vagal control is associated with better social and emotion regulation, while lower vagal control has been correlated with behavioral problems in children (Porges et al., 1996), and depression (Chambers

& Allen, 2002) and anxiety disorders, like social phobia, in adults (Lyonsfeld, Borkovec, & Thayer, 1995; Movias & Allen, 2005). Additionally, vagal control can be measured as a state variable, with changes in vagal control observed in response to stimuli that necessitate social or emotional regulation (Austin et al., 2007).

Porges' poly-vagal theory (1995; for a review see Porges, 2007) proposes that the myelinated vagus works as a vagal brake to rapidly engage or disengage to mobilize or calm an individual. The myelinated vagus's role in inhibiting the sympathetic nervous system's influences on the heart and dampening HPA axis activity allows an individual to engage or disengage with others to promote calm states. Respiratory Sinus Arrhythmia (RSA) represents the variability in heart period related to inspiration and expiration, and is widely used as an index of vagal control, as it has been found that high frequency components of Heart Rate Variability (HRV) in the respiratory range largely reflect variation in vagal sinoatrial control and is an index of parasympathetic cardiac control (Bernston, Quigley, & Lozano, 2007).

In the context of coping with negative life events, high trait levels of vagal control have been associated with tonic positive emotionality (Oveis et al., 2009), cardiac recovery from social stress (Souza et al., 2007), and more effective use of certain coping strategies, like emotional disclosure (O'Connor, Allen, & Kaszniak, 2005). Conversely, O'Connor, Allen, and Kaszniak (2002) have found that lower levels of HRV, often used as an index of vagal control, is related to depression and (marginally significantly) a more passive coping style among bereaved individuals.

O'Connor, Allen, & Kaszniak (2005) investigated individual differences in vagal control and the effectiveness of written disclosure for coping with bereavement. They assigned participants to either a disclosure or control writing task in which they wrote for 20 minute time periods each day for three days over the course of three weeks. Participants' depression, anxiety, positive and negative affect, and grief reactions were measured at each writing session, one week, and one month after the writing sessions. Participants in the disclosure group focused on the death of someone close and the associated thoughts and emotions in their writing. Participants in the control group wrote about their day. Results indicated that participants with high vagal control benefitted from the disclosure writing exercise and showed improvement in BDI scores beyond that of the control participants. Participants with low baseline vagal control did not benefit in the same way from the emotional disclosure exercises.

In addition to its use as a trait variable, vagal control as a state variable can be used as an outcome variable, as in Martens et al. (2010) to measure active regulation and recovery. Martens et al. (2010) gave personality feedback that either raised or lowered participants' self-esteem and measured vagal control. They found that the positive feedback slightly increased vagal control relative to the negative feedback (Martens et al., 2010). Similarly, we used RSA to determine vagal control, which we expected to correlate with cardiovascular recovery to baseline.

The present study builds upon initial self-report data to investigate whether positive emotion eliciting activities aid in physiological recovery from sadness. Soenke and Greenberg (2013) found that engaging in positive emotion eliciting activities following writing about the death of someone close decreased feelings of sadness and guilt and increased positive emotion. As a follow up, this study investigated whether positive emotion eliciting activities facilitate the physiological, in addition to the subjective, recovery from feelings of sadness and grief. To do this, we utilized both ECG and EMG to investigate whether positive emotion eliciting activities produced changes in people's physiological, as well as self-reported experience of sadness.

Given the ability of EMG to differentiate specific emotions, and its sensitivity, we examined differences between conditions and recovery based on the activities in facial muscle activation. Our hypotheses for Study 1 were that we would observe greater activity in the corrugator supercilii muscle region, reflecting greater sadness, in response to thinking about the death of someone close, but not a neutral event. We predicted this increase in activity would decrease among sad participants engaging in the positive emotion eliciting coping activity, but remain high for sad participants engaging in the neutral or grief work activities. Simultaneously, we expected an increase in the zygomaticus major and orbicularis oculi muscle regions, reflecting increased positive emotion, in response to the positive emotion eliciting activity, but not the neutral or grief work activities. For participants in the neutral emotion induction condition, we did not expect any great change in facial muscle activity in response to the emotion induction. Among these participants, we predicted that the positive emotion eliciting activity would increase activity in the zygomaticus major and orbicularis oculi muscle regions, reflecting an increase in positive emotion, while the grief work activity would increase activity in the corrugator supercilii muscle region, reflecting an increase in sadness.

In addition to ascertaining physiological recovery from sadness in response to our positive emotion eliciting activity, we examined whether trait levels of vagal control are related to the effectiveness of the positive emotion eliciting activity in promoting emotional recovery. Individuals with high trait levels of vagal control have been shown to use certain types of coping strategies more effectively (O'Connor, Allen, & Kaszniak, 2005). We predicted that this would also be the case with positive emotion eliciting activities. We hypothesized that for participants with high vagal control, the positive emotion eliciting activities would be more effective at decreasing self-report feelings of sadness and guilt, and increasing positive emotion.

Method

Participants

Participants in this study were 123 (31 males, 92 females) University of Arizona undergraduate students enrolled in introductory psychology courses. Using the mass survey we invited only students who respond “yes” to the question “Have you ever experienced the death of a person you are close to?” to participate in the study. Participants were randomly assigned to one of six experimental conditions in a 2(Emotion: sadness, neutral) x 3(Activity: Funny, neutral, grief work). Thirteen participants were removed from all analyses because they had not experienced the death of someone close. For an additional five, self-report data was unavailable because of technical problems with DMDX. Thirteen more had problems with their EMG recordings and so were not included in those results. An additional 11 participants had problems with their ECG recordings and so were not included in the results for HR and RSA, and Matlab failed to calculate RSA for an additional 2 participants for one time period and so were not included in the analyses for RSA.

Materials and Procedure

Participants were brought into the lab individually for an hour long study. The experimenter, who was blind to conditions, informed participants that they were taking part in a study examining how different personality characteristics relate to memories for events in people’s lives. After signing a consent form, participants completed the study alone in a quiet room. All began the study with a 5-minute free-respiration resting period during which electrocardiograph (ECG) and facial electromyography (fEMG) data were collected. The ECG was recorded using a Synamps^2 System, attaching Ag-AgCl electrodes below the left and right collar bones. Using the Synamps^2 System, the heart series was amplified 1000 times and sampled at 2000 Hz then down sampled to 500 Hz prior to filtering and cleaning. It was then digitally filtered with a band pass filter of .10 to 50 Hz. Using the original ECG series collected for each period for each participant, interbeat intervals (IBI) were estimated, and where necessary, corrected for artifacts by hand screening. Using the CMETX software (Allen, Chambers, & Towers, 2007) the IBI values were used to calculate the log-transformed respiratory sinus arrhythmia (LogRSA) to index vagal control (Berntson, Cacioppo, & Quigley, 1993).

Throughout the study, participants' facial EMG was measured using nonpolarizing silver-silver chloride electrodes placed according to the locations outlined by Fridlund & Cacioppo (1986). The muscle groups measured in this study were the corrugator supercilii, located in the center of the forehead just above the eyebrows, the zygomaticus major, located on the sides of the face below the cheekbone, above the jaw, and the orbitus oculi, the muscles around the eye measured at a location just below the eye slightly toward the outer side of the face. It was filtered using a high pass of 15 Hz to reduce noise, decrease ECG artifact, and reduce cross talk between electrodes.

Because EMG signal varies widely between individuals, we calculated z scores for subjects EMG activity across the study to compare participants' muscle activity for each time period of the study. Analyses were done within subject, to measure change in the activity of the muscle groups of interest in response to both the emotional primes and the coping related activities. Between subjects comparisons were also made to look at the condition by activity interaction on EMG activity.

Following the initial baseline recording, participants were presented with the experimental emotion induction, during which ECG and EMG were be recorded. Participants were asked to write about one of two personal experiences designed to be a mood induction, used previously by Soenke & Greenberg (2013). Half of the participants wrote about a sad experience, the death of someone close to them, and half wrote about a neutral control topic, grocery shopping. Participants in the sad condition were prompted with: “In the space below please write about a time in which someone you are close to passed away. Describe in detail your thoughts, actions, and emotions immediately upon learning of their death and in the week that followed their death.” Participants in the neutral condition were prompted with: “In the space below please write about a time in which you went grocery shopping. Describe in detail your thoughts, actions, and emotions as you did your grocery shopping and after you got home with your groceries.” To verify that the mood induction had the desired impact on emotions, participants rated their emotions immediately after the emotion induction on a scale of 1(very slightly or not at all) to 5(extremely) for two positive emotions (excited and enthusiastic, r = 0.82, $p < .001$), two indicators of sadness (sad and downhearted, r = 0.52, $p < .001$), and two guilt related emotions (guilty and blameworthy, r = 0.66, $p < .001$) taken from the PANAS (Watson, Clark, & Tellegen, 1988) and used previously by Soenke & Greenberg (2013).

After the initial emotion induction, participants were randomly assigned to read one of three different articles: a funny article, a neutral article, and an article about coping with loss designed to map on to grief work. These reading materials were designed to approximate coping activities. To minimize demand, this article was presented as part of a memory task, and participants were told they would need to remember information from the article for later in the study. After the article, participants rated their current emotions again, on the same scale of 1(very slightly or not at all) to 5(extremely) for two positive emotions (excited and enthusiastic, r = 0.29, p = .002), two indicators of sadness (sad and downhearted, r = 0.70, $p < .001$), and two guilt related emotions (guilty and blameworthy, $r = 0.78$, $p < .001$). Participants then completed a final resting period, which was framed as another calibration of the physiological equipment. This second free-respiration resting period lasted five minutes, and was designed to be a recovery period during which the effects of the articles on physiological responding was observed.

Following this resting period, participants completed some questions about the person whose death they experienced, including how long ago the death occurred, the age of the person who died, the participant's kinship to the person who died, and the manner of their death. They also completed one last questionnaire: the Texas Revised Inventory of Grief (TRIG; Faschingbauer, 1981). The TRIG is designed to assess grief as a present emotion of longing, as well as a past personal experience. It includes Past Behavior (8 items; e.g. "I found it hard to sleep after the person died.") and Present Feelings (13 items; e.g. "I can't avoid thinking about the person who died.") subscales. Responses range from 1(completely false) to 5(completely true). Internal consistency for this scale was good ($\alpha = 0.80$) and consistent with previous findings ($\alpha = .77$-$.87$; Faschingbauer, 1981). After completing the materials, participants were thoroughly probed for suspicion and then fully debriefed.

Results

Before testing the hypotheses for this study, we conducted separate ANOVAs for condition (sad, neutral) on emotional responses at time 1, immediately following the writing task to determine that the mood inductions were achieving the desired emotions. For participants ratings of sadness, participants who wrote about the death of someone close rated themselves as significantly more sad ($M = 4.50$, $SD = 1.91$) than participants in the neutral condition ($M = 3.47$, $SD = 1.75$) $F(1, 104) = 8.26$, $p = 0.005$. The opposite was true for participants ratings of positive emotions, with participants who wrote about the death of someone close rating themselves significantly lower in positive emotions (*M* = 3.24, *SD* = 1.94) than participants in the neutral condition (*M* = 5.64, *SD* = 2.06) $F(1, 104) = 37.88$, $p < 0.001$. Participants did not differ by condition on their ratings for feelings of guilt $F(1,105) = 0.13$, $p = 0.72$.

To look at subjective emotional recovery, we conducted 2(condition: sadness, neutral) x 3(type of activity: positive emotion eliciting, neutral, grief work) ANOVAs on difference scores for each self-reported emotion category (sadness, positive emotions, and guilt) to compare changes in emotion from time one (following the emotional induction) to time two (after each activity). Analyses on ratings of sadness yielded significant main effects for condition $F(1,104) = 18.47$, $p < 0.001$, $\eta^2 = 0.16$ and type of activity $F(2,104) = 14.54$, $p < 0.001$, $\eta^2 = 0.23$. The interaction between condition and type of activity was nearly significant $F(5,104) = 2.86$, $p = 0.06$, $\eta^2 = 0.06$; however, a *Levene's F* test revealed that the homogeneity of variance assumption of ANOVA was not met ($p = 0.002$), so the Welch's F test in combination with Dunnett's T3 test for the pairwise comparisons were used in subsequent analyses for ratings of sadness. The one-way ANOVA for emotional condition (sad, neutral) revealed a significant main effect, *Welch's* $F(1,104) = 15.55$, $p < 0.001$, with participants in the sad condition (*M* = -1.20, *SD* = 1.69) reporting greater decrease in sadness from time one to time two than participants in the neutral condition (*M* = -0.69, *SD* = 1.51). The one-way ANOVA for type of activity (funny, neutral, grief work) also revealed a significant main effect, *Welch's* $F(2,104) = 12.53$, $p < 0.001$, with participants who read the grief work article reporting the least change in sadness, a slight increase (*M* = 0.37, *SD* = 1.10), which is significantly less than those who read the funny article ($t(104) = 4.18$, $p < 0.001$, *M* = -1.03, *SD* = 1.35) or those who read the neutral article ($t(104) = 4.61$, $p < 0.001$, *M* = -1.19, *SD* = 1.58), which both decreased sadness. Participants who read the funny and neutral articles did not differ in their ratings of sadness $t(104) = 0.53$, $p = 0.95$. To investigate the interaction, we performed a one-way ANOVA on the six different conditions (2 emotion conditions x 3 types of activities) and revealed significant differences between the groups *Welch's* $F(5, 104) = 11.40$, $p < 0.001$ (Table 1, Figure 1). Pairwise comparisons using Dunnett's T3 revealed that for participants in the sad conditions, the grief work article resulted in very little change in sadness, significantly less than participants who read the funny article $t(104) = 4.44$, $p = 0.001$ or the neutral article $t(104) = 5.36$, $p = 0.001$. Interestingly, among sad participants, the funny and neutral articles did not differ in their influence on ratings of sadness with both decreasing feelings of sadness about equally, $t(104) = 1.09$, $p = 1$. For participants in the neutral condition, the same comparisons using the Dunnett's T3 did not reveal any significant or marginally significant differences.

For participants ratings of positive emotions, *Levene's F* test revealed no heterogeneity of variance ($p > 0.05$) so a regular 2(emotion condition: sad, neutral) x 3(type of activity: funny, neutral, grief work) ANOVA was performed. For change in ratings of positive emotions there was a nearly significant main effect for type of activity $F(2,104) = 2.62$, $p = 0.08$, $\eta^2 = 0.05$ with participants who read the funny article ($M = 1.03$, $SD = 6.04$) reporting an increase in positive emotion that was significantly different from participants who read the grief work article ($M = -1.03$, $SD = 1.77$) $t(104) = 2.26$, $p = 0.03$, who experienced a decrease in positive emotion. Participants who read the funny article did not differ significantly in change in positive emotion from participants who read the neutral article ($M = 0.46$, $SD = 1.67$) $t(104) = 0.68$, $p = 0.50$, who in turn did not differ from participants who read the grief work article $t(104) = 1.56$, $p = 0.12$. The main effect for condition $F(1,104) = 0.47$, $p = 0.49$ and the interaction $F(2,104) = 1.81$, $p = 0.17$ were not significant (Table 1, Figure 2).

For change in participants ratings of guilt, the main effect for condition $F(1,104) = 3.07$, $p = 0.08$, $\eta^2 = 0.03$, and the interaction between condition and type of activity were nearly significant $F(2,104) = 2.47$, $p = 0.09$, $\eta^2 = 0.05$. The main effect for type of activity was not significant $F(2,104) = 2.22$, $p = 0.12$. Once again, a *Levene's F* test revealed heterogeneity of variance in difference scores for participant's ratings of guilt ($p = 0.01$) so the Welch's F test in combination with Dunnett's T3 test for the pairwise comparisons were used in subsequent analyses for ratings of guilt. A one-way ANOVA for emotional condition (sad, neutral) revealed no differences between participants in the sad ($M = -0.55$, $SD = 1.17$) and neutral ($M = -0.24$, $SD = 0.85$) conditions on decreases in guilt *Welch's* $F(1,104) = 2.43$, $p = 0.12$. A one-way ANOVA for type of activity (funny, neutral, grief work) also revealed no differences between participants' decreases in guilt *Welch's* $F(1,104) = 2.23$, $p = 0.11$. To investigate the interaction, we performed a one-way ANOVA on the six different conditions (2 emotion conditions x 3 types of activities) and revealed significant differences between the groups *Welch's* $F(5, 104) = 2.44$, $p = 0.04$ (Table 1, Figure 3). Pairwise comparisons using Dunnett T3 tests revealed no significant differences between the groups on changes in ratings of guilt.

EMG

To look at physiological recovery, as measured by EMG, we conducted 2(condition: sadness, neutral) x 3(type of activity: positive emotion eliciting, neutral, grief work) x 4(time: baseline, emotion induction, activity, recovery period) repeated measures ANOVAs on each muscle group (corrugator supercilii, zygomaticus major, and orbicularis oculi) to determine changes in muscle activity over the course of the study. Although EMG was measured continuously, we computed standardized z scores using the mean levels of activity for each portion of the experiment; baseline, emotion induction, during the activity, and a recovery period following the activity. *Levene's F* tests revealed heterogeneity of variance in the results for corrugator activity during the emotion induction, activity, and recovery periods (all *p*s < 0.05), and for orbicularis oculi activity during the recovery period ($p < 0.05$).

Corrugator Supercilii Activity

For corrugator activity, there was a significant main effect for time, $F(3, 87) = 47.70$, $p < 0.001$, $\eta^2 = 0.35$, with corrugator activity during baseline ($M = -0.39$, $SD = 0.78$) significantly lower than during the emotion induction ($M = 0.33$, $SD = 0.73$) $t(92) = 5.88$, $p < 0.001$, and during the activity ($M = 0.66$, $SD = 0.73$) $t(92) = 7.72$, $p < 0.001$. Corrugator activity during the emotion induction was also significantly lower than during the activity $t(92) = 2.89$, $p = 0.005$, and significantly higher than during the recovery period ($M = -0.55$, $SD = 0.61$) $t(92) = 7.70$, $p < 0.001$. Corrugator activity during the activity was significantly higher than during the recovery period $t(92) = 11.52$, $p < 0.001$, which did not differ from baseline $t(92) = 1.42$, $p > 0.10$.

The two way interaction for time by condition was significant $F(3, 87) = 4.06$, $p = 0.008$, $\eta^2 = 0.05$ (Table 2, Figure 4). At baseline, participants in the sad and neutral conditions did not differ in their corrugator activity $t(92) = 0.88$, $p = 0.38$. Consistent with hypotheses, during the emotional condition, participants in the sad condition exhibited significantly more corrugator activity than participants in the neutral condition $t(92) = 3.27$, $p = 0.002$. During the activity, participants in the sad condition had significantly lower corrugator activity than participants in the neutral condition $t(92) = 2.08$, $p = 0.04$. During the recovery period, participants did not differ in corrugator activity $t(92) = 0.25$, $p = 0.80$. Among sad participants, corrugator activity increased from baseline to during the emotion induction $t(92) = 6.11$, $p < 0.001$, remained elevated during the activity $t(92) = 0.36$, $p = 0.72$, and then returned back to baseline during the recovery period $t(92) = 7.42$, $p < 0.001$. Among neutral participants, corrugator activity increased from baseline to during the emotion induction $t(92) = 2.31$, $p = 0.02$, increased further during the activity $t(92) = 4.32$, $p < 0.001$, and then returned back to baseline during the recovery period $t(92) = 8.79$ $p < 0.001$.

The interaction for time by activity approached significance $F(6, 87) = 1.90$, $p = 0.08$, $\eta^2 = 0.04$ (Table 3, Figure 5). Consistent with hypotheses, during the activity, participants who read the grief work article had significantly greater corrugator activity than participants who read the funny article $t(92) = 3.02$, $p = 0.003$ and participants who read the neutral article $t(92) = 2.49$, $p = 0.02$. Participants who read the funny and neutral articles did not differ in their corrugator activity during the activity $t(92) = 0.54$, $p = 0.59$. Participants did not differ significantly in corrugator activity by activity condition during any of the other time periods. When examining corrugator activity by activity condition across time periods, both the funny and neutral conditions showed similar patterns of results: an increase in activity from baseline during the emotion induction that stabilizes through the activity before returning back to baseline (Figure 1). For the grief work article, participants showed an increase in activity from baseline during the emotion induction, an additional increase during the activity, and then a return back to baseline.

The main effects for emotion condition $F(1, 87) = 0$, $p = 0.99$, $\eta^2 = 0$, activity condition $F(2, 87) = 0.47$, $p = 0.62$, $\eta^2 = 0.01$, the two-way interaction between condition and activity $F(2, 87) = 0.47$, $p = 0.62$, $\eta^2 = 0.01$, and the three way interaction between emotion condition, activity condition, and time $F(2, 87) = 1.54$, $p = 0.22$, $\eta^2 = 0.03$ were not significant. Although the three way interaction was not significant, we examined the pairwise comparisons to investigate our hypotheses about the role of positive emotion in physiological recovery.

To investigate this, we first examined participants in the sad condition who read the funny article corrugator activity over the four time periods. Corrugator activity in these participants rose significantly from baseline during the emotion induction $t(92) = 4.07$, $p < 0.001$, showed a slight, non-significant decrease during the activity $t(92) = 0.94$, $p = 0.35$, and then decreased back to baseline during the recovery period $t(92) = 3.55$, $p = 0.01$ (Table 4, Figure 6). Interestingly, patterns in sad participants who read the neutral article looked very similar to those who read the funny article with a nearly significant decrease during the activity $t(92) = 1.75$, $p = 0.08$. Participants in the sad condition who read the grief work article showed a significant increase from baseline during the emotion induction $t(92) = 3.16$, $p = 0.002$, a slight, non-significant increase during the activity $t(92) = 1.63$, $p = 0.11$, and then decreased back to baseline during the recovery period $t(92) = 4.97$, $p < 0.001$. For participants in the neutral condition, no change in corrugator activity was observed during the emotion induction. An increase in corrugator activity from baseline was observed among participants in response to both the neutral $t(92) = 2.77$, $p = 0.007$ and grief work articles $t(92) = 3.43$, $p = 0.001$, but not the funny article during the activity $t(92) = 1.16$, $p = 0.25$. All three conditions decreased significantly back to baseline levels during the recovery period.

Among sad participants during the activity, participants who read the grief work article ($M = 0.87$, $SD = 0.59$) had significantly greater corrugator activity than the neutral activity ($M = 0.29$, $SD = 0.79$) $t(92) = 2.31$, $p = 0.02$, and nearly significantly greater corrugator activity than participants who read the funny article ($M = 0.38$, $SD = 0.62$) $t(92) = 1.93$, $p = 0.06$. The funny and neutral articles did not differ $t(92) = 0.37$, $p = 0.71$. Among participants in the neutral condition during the activity, participants who read the grief work article ($M = 1.12$, $SD = 0.41$) had significantly greater corrugator activity than the funny article ($M = 0.52$, $SD = 0.87$) $t(92) =$

2.32, $p = 0.02$. The neutral article ($M = 0.89$, $SD = 0.72$) did not differ from the funny article $t(92) = 1.09$, $p = 0.28$ or the grief work article $t(92) = 1.25$, $p = 0.22$.

Zygomaticus Major Activity

For zygomaticus major activity only the two-way interaction for time by activity reached significance $F(6, 87) = 3.71$, $p = 0.001$, $\eta^2 = 0.08$ (Table 5, Figure 7). The main effects for time $F(3, 87) = 0.72$, $p = 0.54$, $\eta^2 = 0.008$, condition $F(1, 87) = 0.15$, $p = 0.70$, $\eta^2 = 0.002$, and activity $F(2, 87) = 0.75$, $p = 0.47$, $\eta^2 = 0.02$ were not significant. The two-way interactions for condition by time $F(3, 87) = 0.46$, $p = 0.71$, $\eta^2 = 0.005$ and condition by activity $F(6, 87) = 0.58$, $p = 0.56$, $\eta^2 = 0.01$ were also not significant. The three-way interaction for condition by activity by time was also not significant $F(6, 87) = 0.68$, $p = 0.67$, $\eta^2 = 0.01$.

When further investigating the two-way interaction for time by activity, pairwise comparisons revealed unexpected differences at baseline between the grief work ($M = -0.50$ $SD = 0.79$) and the neutral ($M = 0.20$ $SD = 0.99$, $t(92) = 2.24$, $p = 0.03$), and funny ($M = 0.02$ $SD = 0.86$, $t(92) = 2.94$, $p = 0.004$) articles. The neutral and funny articles did not differ significantly at baseline $t(92) = 0.75$, $p = 0.45$. During the emotion induction, only the funny and neutral articles differed significantly $t(92) = 2.24$, $p = 0.03$, with the funny article showing less zygomatic activity. During the activity none of the conditions differed significantly. During the recovery period, the grief work article ($M = 0.42$ $SD = 0.67$) led to more zygomatic activity than both the neutral article ($M = -0.29$ $SD = 0.75$) $t(92) = 3.65$, $p < 0.001$, and the funny article ($M = -0.04$ $SD = 0.81$), $t(92) = 2.36$, $p = 0.02$ The neutral and funny articles did not differ significantly at baseline $t(92) = 1.34$, $p = 0.18$.

When participants' changes in zygomaticus major activity were examined over time by activity condition, participants who read the funny article showed no changes in zygomaticus major activity, contrary to hypotheses. Participants who read the neutral article decreased in their zygomaticus major activity from baseline to the recovery period $t(92) = 2.13$, $p = 0.04$, and from the emotion induction to the recovery period $t(92) = 2.75$, $p = 0.007$. Participants who read the grief work article increased in their zygomaticus major activity from baseline to the emotion induction $t(92) = 2.53$, $p = 0.01$ and again in the recovery period $t(92) = 3.78$, $p < 0.001$. They also increased in their zygomaticus major activity from during the activity to the recovery period $t(92) = 1.96$, $p = 0.05$.

Although the three-way interaction was not significant, we examined several pairwise comparisons to help answer our hypotheses about the role of positive emotions in physiological recovery (Table 6, Figure 8). Although we predicted that the funny article would increase zygomaticus activity among sad participants compared to the other articles, no significant differences were observed during the activity. Among neutral participants the pattern was more consistent with hypotheses. During the activity, participants who read the funny article (M = 0.37, SD = 0.99) had nearly significantly higher zygomaticus activity compared to both the neutral article (M = -0.20, SD = 0.78) $t(92) = 1.70$, $p = 0.09$ and the grief work article (M = -0.25, SD = 0.87) $t(92) = 1.80$, $p = 0.075$. The neutral and grief work articles did not differ $t(92) = 0.16$, $p = 0.87$.

Although we did not see the predicted changes in zygomaticus activity during the activity, correlations with self-report emotion indicated that during the activity, rating of positive emotion was significantly positively correlated with zygomaticus activity $r = 0.265$, $p = 0.01$. Muscle activity did not correlate with self-report data for any of the other emotion and muscle group combinations.

Orbicularis Oculi

For orbicularis oculi muscle activity there was a significant main effect for time $F(3, 87) = 11.13$, $p < 0.001$, $\eta^2 = 0.11$ with orbicularis activity increasing from baseline to during the emotion induction $t(92) = 3.81$, $p < 0.001$, remaining elevated during the activity $t(92) = 0.15$, $p = 0.88$, and then returning to baseline during the recovery period $t(92) = 4.17$, $p < 0.001$. There was also a nearly significant main effect for condition $F(1, 87) = 3.64$, $p = 0.06$, $\eta^2 = 0.04$ with participants in the sad condition showing less orbicularis activity than participants in the neutral condition. This is consistent with the idea that orbicularis oculi activity is associated with expression of genuine positive emotion.

The main effect for activity $F(2, 87) = 1.74$, $p = 0.18$, $\eta^2 = 0.038$, the two-way interactions for condition by activity $F(2, 87) = 0.03$, $p = 0.97$, $\eta^2 = 0.001$, condition by time $F(3, 87) = 1.66$, $p = 0.17$, $\eta^2 = 0.02$, and activity by time $F(6, 87) = 1.50$, $p = 0.18$, $\eta^2 = 0.03$, and the three-way interaction for condition by activity by time $F(6, 87) = 1.39$, $p = 0.22$, $\eta^2 = 0.03$ were not significant. Although the three-way interaction was not significant, we examined several pairwise comparisons to help answer our hypotheses about the role of positive emotions in physiological recovery (Table 7, Figure 9). Although we predicted that the funny article would increase orbicularis activity along with zygomaticus activity among sad participants compared to the other articles, no significant differences were observed during the activity for participants in the sad or neutral conditions.

Results for Cardiovascular Recovery

In order to measure cardiovascular recovery, we conducted 2(condition: sadness, neutral) x 3(type of activity: funny, neutral, grief work) x 4(time: baseline, emotional induction, activity, recovery period) repeated measures ANOVAs on HR and RSA.

Heart Rate

The results for HR revealed a significant main effect for time $F(3, 93) = 38.83$, $p < 0.001$, $\eta^2 = 0.30$, with HR during baseline ($M = 78.79$, $SD = 12.39$) significantly lower than during the emotion induction ($M = 81.90$, $SD = 11.65$) $t(98) = 6.43$, $p < 0.001$, and significantly higher than during the activity ($M = 77.99$, $SD = 11.70$) $t(98) = 2.18$, $p = 0.03$. HR during the emotion induction was also significantly higher than during the activity $t(98) = 9.64$, $p < 0.001$, and the recovery period ($M = 78.79$, $SD = 11.43$) $t(98) = 8.96$, $p < 0.001$. HR during the activity was significantly lower than during the recovery period $t(98) = 2.20$, $p = 0.03$, which did not differ from baseline $t(98) = 0.48$, $p = 0.63$. Additionally, the main effect for condition was approaching significance $F(1, 93) = 2.85$, $p = 0.095$, $\eta^2 = 0.03$, with higher HR among participants in the sad condition ($M = 81.16$, $SD = 15.37$) compared to the neutral condition ($M = 77.38$, $SD = 16.18$).

The interaction between condition and type of activity was significant $F(2, 93) = 3.50$, $p = 0.03$, $\eta^2 = 0.07$ (Table 8). For participants in the sad condition, those who read the neutral article had a significantly higher HR than participants who read the funny article $t(98) = 2.49$, $p = 0.015$, or the grief work article $t(98) = 2.77$, $p = 0.007$. HR did not differ for participants in the sad condition who read the funny or grief work articles $t(98) = 0.40$, $p = 0.69$. Among participants in the neutral condition, there were no significant differences for HR. When comparing participants in the sad and neutral conditions in each type of activity, only differences were discovered among those who read the neutral article, with participants in the neutral condition showing lower HR than those in the sad condition $t(98) = 3.03$, $p = 0.003$. Participants who read the funny or grief work articles did not differ by condition in their HR.

For HR, the main effect for type of activity $F(2, 93) = 2.08$, $p = 0.13$, $\eta^2 = 0.04$, the two-way interactions for time by condition $F(1, 93) = 0.78$, $p = 0.38$, $\eta^2 = 0.008$, and time by type of activity $F(2, 93) = 0.08$, $p = 0.92$, $\eta^2 = 0.002$, and the three way interaction for condition by type of activity by time $F(2, 93) = 1.66$, $p = 0.20$, $\eta^2 = 0.03$ were not significant.

Although the three-way interaction was not significant, we examined several pairwise comparisons to help answer our hypotheses about the role of positive emotions in physiological recovery (Table 9, Figure 10). Among participants in the sad condition, those who read the funny article showed patterns consistent with our hypotheses with a significant increase in HR from baseline in response to the emotion induction $t(98) = 2.73$, $p = 0.008$, followed by a significant decrease in response to the funny article $t(98) = 4.60$, $p < 0.001$ which remained lower during the recovery period $t(98) = 0.61$, $p = 0.55$. Participants' HR during the activity was similar to during baseline $t(98) = 1.43$, $p = 0.16$, indicating that the funny article appeared to aid in HR recovery.

Contrary to hypotheses, when HR for participants in the sad condition who read the neutral and grief work articles were examined over time, a similar pattern of results emerged. Additionally, the same pattern of results was observed for participants in the neutral condition for all three of the activity types.

Because all of the groups showed similar patterns of results, additional analyses were run on difference scores to determine first: whether participants in the sad condition reported a greater increase in HR in response to the emotion induction, and second: whether the funny article led to the greatest decrease in HR for the sad participants. To investigate whether participants in the sad condition reported a greater increase in HR in response to the emotion induction, a 2(condition: sad, neutral) x 3(activity: funny, neutral, grief work) ANOVA was run on difference scores calculated by subtracting baseline HR from HR during the emotion induction. This analysis revealed no significant main effects or interactions, indicating that our hypothesis that HR would increase among participants in response to the sad, but not the neutral emotion induction was no supported. To investigate whether the funny article led to the greatest decrease in HR for the sad participants a 2(condition: sad, neutral) x 3(activity: funny, neutral, grief work) ANOVA was run on difference scores calculated by subtracting HR during the emotion induction from HR during the activity. Again, no significant main effects or interactions were found, indicating that the activities did not differ in the degree to which they lowered participants' HR.

Respiratory Sinus Arrhythmia

Just as HR was examined as an index of cardiovascular recovery, RSA was similarly investigated using a 2(condition: sadness, neutral) x 3(type of activity: funny, neutral, grief work) x 4(time: baseline, emotional induction, activity, recovery period) repeated measures ANOVA. Again, the main effect for time was significant $F(3, 91) = 47.12$, $p < 0.001$, $\eta^2 = 0.34$ with RSA during baseline ($M = 6.14$, $SD = 1.09$) significantly higher than during the emotion induction ($M = 5.53$, $SD = 1.04$) $t(96) = 7.68$, $p < 0.001$, which was significantly lower than during the activity ($M = 6.22$, $SD = 1.07$) $t(96) = 9.63$, $p < 0.001$, and the recovery period ($M = 6.13$, $SD = 1.00$) $t(96) = 9.09$, $p < 0.001$. RSA during the baseline, activity, and recovery periods did not differ significantly.

The main effect for type of activity was also significant $F(2, 91) = 3.46$, $p = 0.036$, $\eta^2 = 0.07$ with participants who read the neutral article ($M = 5.65$, $SD = 1.69$) showing significantly lower RSA than participants who read the grief work article ($M = 6.29$, $SD = 1.75$) $t(96) = 2.57$, $p = 0.01$, and nearly significantly lower RSA than participants who read the funny article ($M = 6.08$, $SD = 1.62$) $t(96) = 1.79$, $p = 0.08$. The funny and grief work articles did not differ $t(96) = 0.86$, $p = 0.39$.

The interaction for condition by type of activity was also significant $F(2, 91) = 3.34$, $p = 0.04$, $\eta^2 = 0.07$ (Table 10). For participants in the sad condition, those who read the neutral article had a significantly lower RSA than participants who read the funny article $t(98) = 3.04$, $p = 0.003$, or the grief work article $t(98) = 2.15$, $p = 0.03$. RSA did not differ for participants in the sad condition who read the funny or grief work articles $t(98) = 0.80$, $p = 0.42$. Among participants in the neutral condition, participants who read the funny article had nearly significantly lower RSA than participants who read the grief work article $t(98) = 1.96$, $p = 0.053$. This was the only difference observed among neutral participants. When comparing participants in the sad and neutral conditions in each type of activity, no significant differences were observed for RSA.

The main effect for condition $F(1, 91) = 0.48$, $p = 0.49$, $\eta^2 = 0.005$, the two-way interactions for time by condition $F(3, 91) = 0.29$, $p = 0.84$, $\eta^2 = 0.003$, and time by type of activity $F(6, 91) = 0.44$, $p = 0.85$, $\eta^2 = 0.01$, and the three-way interaction for condition by type of activity by time $F(6, 91) = 3.34$, $p = 0.37$, $\eta^2 = 0.02$ were not significant.

Although the three-way interaction was not significant, we once again examined several pairwise comparisons to help answer our hypotheses about the role of positive emotions in physiological recovery (Table 11, Figure 11). Similar to the results for HR, a pattern emerged for all of the six conditions in which RSA decreased significantly from baseline to the emotion induction, then increased during the activity back to baseline levels and returned to baseline levels during the recovery period. Because all of the groups showed similar patterns of results, we again ran additional analyses on difference scores to investigate differences in change in RSA. To investigate whether participants in the sad condition reported a greater increase in RSA in response to the emotion induction, a 2(condition: sad, neutral) x 3(activity: funny, neutral, grief work) ANOVA was run on difference scores calculated by subtracting baseline HR from HR during the emotion induction. This analysis revealed no significant main effects or interactions, indicating that our hypothesis that RSA would increase among participants in response to the sad, but not the neutral emotion induction was no supported. To investigate whether the funny article led to the greatest decrease in RSA for the sad participants a 2(condition: sad, neutral) x 3(activity: funny, neutral, grief work) ANOVA was run on difference scores calculated by subtracting RSA during the emotion induction from RSA during the activity. Again, no significant main effects or interactions were found, indicating that the activities did not differ in the degree to which they lowered participants' RSA.

Vagal Control

To examine the role of vagal control in the effectiveness of positive emotion eliciting activities for coping with sadness we used a median split on participants RSA during baseline to categorize participants as either low or high vagal control and looked at changes in self-reported emotions and HR. We were interested in whether participants with higher vagal control at baseline would experience more rapid recovery from feelings of sadness after reading the funny article compared with participants with lower vagal control.

Vagal Control on Self-Report

To examine the role of vagal control on self-report recovery from sadness we conducted three 2(vagal control: lower, higher) x 2(condition: sad, neutral) x 3(type of activity: funny, neutral, grief work) ANOVAs on difference scores for sadness, positive emotions, and guilt. The ANOVAs for sadness and positive emotion did not reveal any significant main effects or interactions for vagal control on participants' change in sadness or positive emotions from after the emotion induction to after the activity. The ANOVA for guilt revealed a nearly significant main effect for vagal control $F(1, 87) = 3.32$, $p = 0.07$, $\eta^2 = 0.04$ with participants low in vagal control reporting greater decreases in guilt ($M = -0.64$, $SD = 1.62$) than participants high in vagal control ($M = -0.23$, $SD = 1.54$). None of the other main effects or interactions for guilt were significant.

Vagal Control on Heart Rate

To examine the role of vagal control on physiological recovery we conducted a 2(vagal control: lower, higher) x 2(condition: sad, neutral) x 3(type of activity: funny, neutral, grief work) x 4(time: baseline, emotion induction, activity, recovery period) repeated measures ANOVA on HR. Analyses revealed a main effect for time $F(1, 87) = 21.95$, $p < 0.001$, $\eta^2 = 0.20$, a nearly significant main effect for emotion $F(1, 87) = 3.06$, $p = 0.08$, $\eta^2 = 0.03$, a significant interaction for time by activity $F(6, 87) = 2.15$, $p = 0.048$, $\eta^2 = 0.05$, and a nearly significant interaction for condition by activity $F(2, 87) = 3.05$, $p = 0.052$, $\eta^2 = 0.07$. Because all of these were discussed in the HR results, we will focus this section on the findings for vagal control.

Analyses revealed a significant main effect for vagal control $F(1, 87) = 32.22$, $p < 0.001$, $\eta^2 = 0.99$, with participants lower in vagal control reporting higher levels of HR ($M = 85.20$, $SD = 14.63$) than participants with higher levels of vagal control ($M = 73.68$, $SD = 13.94$). There was also a significant interaction for time by vagal control $F(3, 87) = 3.08$, $p = 0.02$, $\eta^2 = 0.03$ (Table 12, Figure 12). While participants with lower vagal control had higher levels of HR over all of the time periods, participants with low vagal control showed significant differences in HR at all the time periods, where participants with high vagal control only exhibited higher HR during the emotion induction.

The three-way interaction for vagal control by condition by activity was approaching significance $F(2, 87) = 2.67$, $p = 0.08$, $\eta^2 = 0.06$ (Table 13). Participants with lower vagal control in the sad condition who read the funny article had significantly higher HR than participants with higher vagal control $t(98) = 3.71$, $p < 0.001$. Results were similar for participants in the sad condition who read the grief work article $t(98) = 3.11$, $p = 0.003$, participants in the neutral condition who read the funny article $t(98) = 2.85$, $p = 0.005$, and participants in the neutral condition who read the neutral article $t(98) = 3.63$, $p < 0.001$. Participants in the sad condition who read the neutral article $t(98) = 0.77$, $p = 0.44$ and participants in the neutral condition who read the grief work article $t(98) = 0.72$, $p = 0.47$ did not differ by level of vagal control on HR.

The main effect for type of activity $F(2, 87) = 2.08$, $p = 0.13$, $\eta^2 = 0.05$, the two-way interactions for vagal control and condition $F(1, 87) = 0.006$, $p = 0.9$, $\eta^2 = 0$, vagal control and type of activity $F(2, 87) = 0.66$, $p = 0.52$, $\eta^2 = 0.02$, time and condition $F(3, 87) = 0.32$, $p = 0.81$, $\eta^2 = 0.004$, the tree-way interactions for time by vagal control by condition $F(3, 87) = 1.09$, $p = 0.36$, $\eta^2 = 0.01$, time by vagal control by activity $F(6, 87) = 1.25$, $p = 0.28$, $\eta^2 = 0.03$, time by condition by activity $F(6, 87) = 0.79$, $p = 0.58$, $\eta^2 = 0.02$, and the four-way interaction for time by vagal control by condition by activity $F(6, 87) = 0.41$, $p = 0.88$, $\eta^2 = 0.01$ were not significant.

Discussion

Initial studies investigating the role of positive emotion eliciting activities for coping with feelings of sadness have found support for their effectiveness at decreasing self-reported feelings of sadness and guilt, and increasing positive emotion (Soenke & Greenberg, 2013). Additionally previous research has shown that positive emotion can facilitate physiological recovery from experiences of fear and anxiety (Fredrickson & Levenson, 1998; Tugade & Fredrickson, 2004). The current study investigated whether positive emotion eliciting activities would produce any changes in physiological, in addition to self-reported emotional recovery from experiences of sadness. Additionally, trait levels of vagal control have been shown to play an important role in both the experience of positive emotion (Kok & Fredrickson, 2010; Oveis et al., 2009) and the effectiveness of certain types of coping strategies (O'Connor, Allen, & Kaszniak, 2005), so this study explored the role of trait levels of vagal control on the effectiveness of positive emotion eliciting activities for coping with sadness.

Our first goal for this study was to replicate previous research indicating that positive emotion eliciting activities can alleviate self-report feelings of sadness and guilt, and increase positive emotions following writing about an experience of sadness (Soenke, Greenberg & O'Connor, 2014). For this study we predicted, consistent with prior research, a significant decrease in sadness for participants who wrote about the death of someone close and then read a funny article, compared to those who read a neutral or grief work article, or participants who wrote about a neutral experience. While our writing task produced the desired emotional responses, with participants who wrote about the death of someone close reporting higher ratings of sadness and lower positive emotions than those who wrote about a neutral topic, the coping activities produced less straight forward changes in self-reported emotion. As predicted, participants in the sad condition who read the grief work article showed almost no change in ratings of sadness, whereas participants who read the funny article reported a decrease in sadness; but unexpectedly, participants who read the neutral article also reported a decrease in sadness comparable to those who read the funny article. We also predicted that the grief work activity would increase ratings of sadness among neutral participants, and while the results were in a direction consistent with this hypothesis, this difference failed to reach significance.

For change in positive emotion, the funny article produced increases among participants in both the sad and neutral conditions. For ratings of guilt, no significant differences were observed between the conditions.

Despite the lack of significant interactions and pairwise comparisons, when we examine the pattern of results for change in positive emotion among participants in the sad condition, the neutral article has the greatest, albeit non-significant, increase in positive emotions. Similarly, for these participants, the neutral article has the greatest decrease in guilt. These effects of the neutral article seem unique to participants in the sad condition. It seems likely that with more participants and less conservative tests, these differences might achieve significance. This makes one wonder why participants are responding more positively to the neutral article after writing about the death of someone close than after writing about a neutral topic. It is possible that for participants in the sad condition, the neutral article about a highway that goes through the second largest canyon in Arizona may have a peaceful pleasant feel that doesn't feel inappropriate to read about and enjoy in the way that the funny article may. This is in line with Soenke, Greenberg, & O'Connor's (2014) findings that people anticipate that engaging in fun activities following a sad experience will cause them to feel guilty and will not decrease feelings of sadness, whereas activities that are simply distracting aren't viewed so negatively.

Our second goal of this study was to investigate the role of positive emotion eliciting activities in promoting physiological recovery from sadness. We did this in two ways, first by examining change in facial muscle activity, and second, by looking at indices of cardiovascular response. For facial muscle activity we examined three muscle groups, corrugator supercilii, which has been associated with negative emotion, zygomaticus major, which has been associated with positive emotion (Brown & Schwartz, 1980), and orbicularis oculi, which in combination with zygomaticus major activity, has been shown to reflect a more genuine positive emotion (Ekman, Davidson, & Friesen, 1980).

With this in mind, we predicted that we would observe an increase in corrugator activity during the emotion induction for participants in the sad condition, but not the neutral condition. We also predicted that among sad participants, this increase in corrugator activity would return to baseline most quickly for participants who read the funny article, followed by the neutral article, and then the grief work article. For neutral participants we predicted an increase in corrugator activity in response to the grief work article. Results for corrugator activity during the emotion induction supported our hypothesis, with participants in the sad condition showing a more activity than neutral participants. Additionally, during the activity, participants who read the grief work article had significantly more corrugator activity than those who read the funny or neutral articles. Although the three-way interaction for corrugator activity wasn't significant, the pattern of results is consistent with predictions with the exception of participants in the sad condition who read the neutral article. These participants once again look similar to participants who read the funny article, with corrugator activity decreasing among participants in these groups more quickly than those who read the grief work article. These findings are in line with the self-report findings and once again indicate that for participants in the sad condition, the neutral article is being viewed more positively than among neutral participants.

For zygomaticus major and orbicularis oculi activity, we predicted that participants would show increased activity in these muscle groups in response to the funny article, but not the neutral or grief work articles. Our results for zygomaticus and orbicularis activity did not support our hypotheses, and were difficult to find any meaningful interpretation for. The one result that supported our hypothesis was a significant correlation between zygomaticus activity and ratings of positive emotions during the activity. Unexpected differences between conditions at baseline, and between activity conditions during the emotion induction raise concern about systematic differences between participants in the groups unrelated to the experiment's tasks. Additionally, the possibility that mistakes were made during data collection for these muscle groups should be considered. While the placement for the corrugator electrodes is relatively easy, experimenters may have experienced more difficulty and variability in the placement of the electrodes for the zygomaticus major muscle and even the orbicularis oculi muscle, given its proximity to participants' eye.

To measure cardiovascular recovery, we examined HR and RSA. We predicted that we would see an increase in HR for sad participants during the emotion induction, compared to neutral participants, and that this increase in HR would decrease back to baseline most quickly for participants who read the funny article, compared to the neutral and grief work articles. We predicted the opposite pattern for RSA, since it is inversely related to HR.

Our results for HR generally failed to support our hypotheses. Consistent with the idea that feelings of sadness may produce an increase in HR, participants in the sad condition showed generally higher HR throughout the study compared with neutral participants, but this difference was just shy of being significant. The pattern of results for HR indicated that, regardless of condition, participants experienced an increase in HR from baseline in response to the emotion induction, followed by a decrease in HR in response to the activity that remained constant through the recovery period. The results for RSA were similar to HR, with participants showing a decrease in RSA from baseline in response to the emotion induction, followed by an increase in RSA in response to the activity that remained constant through the recovery period. Neither the mood induction nor the type of activity influenced HR or RSA.

Because this pattern occurs across all participants, it raises the question: is there something about the way that participants progress through the experiment and the tasks they are engaged in that can account for this pattern? Perhaps HR increases during the writing task, because participants have a heightened arousal in response to actively engaging in their writing task. The activity, reading an article, and the resting periods are less active, and this difference may be what is reflected in the HR results observed in this study.

While it is unfortunate that our emotion inductions and activities did not lead to differences in HR or RSA, it is not terribly surprising given the conflicting literature on the cardiovascular profile for sadness. As part of a study on physiological profiles for fear and sadness, Kreibig and colleagues (2007) did a review of the literature and uncovered nine studies in which sadness increased HR and four studies in which it decreased. Similarly, the same review revealed five studies in which sadness failed to have any influence on heart rate variability, one that increased it, and one that decreased it (Kreibig et al. 2007). These conflicting results reinforce the need for psychophysiological studies of sadness to include alternatives to cardiovascular indices.

Our third goal for this study was to examine whether trait levels of vagal control played a role in the effectiveness of positive emotion eliciting activities for coping with sadness. We predicted that individuals with higher trait vagal control would be more responsive to the funny article after writing about the death of someone close. We thought we would see faster recovery in both self-reported emotional responses and HR. Our results did not support our hypotheses, and indicated that vagal control did not seem to play a role in either affective reactions to the mood induction and activities in general, or specifically in the effectiveness of positive emotion eliciting activities for coping with sadness. One possibility for why we aren’t seeing the results for vagal control that we expected might be that we have used a median split to separate participants into high and low vagal control. With already small sample sizes, we have created groups that are even smaller and lose some statistical power to detect differences. This was done for ease of interpretability, to best answer our questions about the ways in which vagal control might interact with the type of activity following the sad writing task, and to allow for the examination of our variables at the different time points using repeated measures. A regression analyses using vagal control as a continuous predictor variable might be a more appropriate test, and yield more interpretable results. However, regression would not allow examination of the repeated measures variables, and low power would still be a problem with using regression with vagal control as a continuous variable and dummy coding of the two independent variables, one of which had three levels, and a large number of interaction terms.

Limitations

Unfortunately this study has several prominent limitations that may have contributed to the null, inconclusive, and at times puzzling results. The most obvious limitation is our small sample size. Because of the large design, a large number of participants were needed to test our hypotheses. Given the nature of psychophysiological research, data collection was time consuming, and frequent technical problems resulted in many participants' data being unusable. In the future, greater care will need to be taken to try to prevent loss of data, and more time allowed for data collection.

In addition to our small sample sizes, the design of the experiment has some inherent flaws that may have contributed to some of the problems with results that were observed. First, although the baseline and recovery periods were set time periods of five minutes, participants moved through the writing task and reading the article at their own pace. Some participants read the article very quickly, and so had shorter time periods from which to collect physiological responses. In the future, the study will need to be set up in a way that structures the amount of time that participants have to complete these tasks.

Second, presenting the article as a memory task was effective at encouraging participants to carefully read the article, but may have resulted in participants focusing on the content of the article in an effort to memorize the material, rather than to experience the content more holistically to achieve the emotional experience we were hoping for. Additionally, for some participants, being told they needed to remember the article may have resulted in more anxiety. Perhaps this accounts for some of the elevation in HR observed among neutral participants, as participants more frequently reported during the debrief that this article was difficult to remember. In the future, more consideration will need to be given to designing an experiment that will better control for influences on physiological responses due to the cover story and context of the study independent of the experimental conditions.

Another limitation of the study pertains to the articles used, particularly the neutral article. The positive article did lead to more positive emotion than the neutral article in the control condition. However, as noted previously, for sad participants, the neutral article may have seemed rather positive. This is a difficult problem, for two reasons. First, after a sadness induction, anything not sad may seem, by contrast, positive. Second, because an article with no positive aspects is likely to be viewed as tedious and boring, it could be viewed as more negative than neutral.

Future Directions

There are many future directions for this study, some of which could be investigated with further analysis of the current data. While it would be ideal to re-run the current study, assigning time frames for the different experimental tasks, running more participants per condition, and perhaps returning to the activities used previously by Soenke, Greenberg, & O'Connor (2014), many new analyses can be run to investigate additional questions using the current data. First, as mentioned previously, new analyses should be run on vagal control as a continuous predictor variable.

Additional analyses can also be run on EMG activity continuously. When EMG data is collected, it is collected over the entire duration of the experiment and emotion may be reflected in bursts of activity rather than in using means for the entire duration of experimental tasks. Analyses that look at these bursts of activity, or that focus on time points at which individual muscle groups show change in activity independent of other muscle groups may yield unique results that can't be observed by analyzing the means, as we have done here.

Another future direction that could be taken is to look at how variables related to the person's death, like how long it has been since they died, the manner in which they died, the relationship to the person who died, and their score on the TRIG, may influence participants' emotional responses to both the writing task and the different activities. However, a larger sample would be needed to expect to find reliable relationships of this nature. Additionally, this study was conducted on participants who had experienced the death of someone close at some point during their lives. We did not control for how long ago the death occurred, their relationship to the person, or the type of death. One can imagine that the experience of losing a parent, sibling, or close friend to a violent death or suicide is different from losing a grandparent or more distant relative to old age. Future studies should be done with participants who have experienced a more recent loss and are more actively coping with the death. Similarly, recruiting participants who have all experienced a certain kind of loss (for example the loss of a spouse to illness) can help to control for some of these variables.

If any of these new analyses reveal more promising findings for vagal control contributing to a unique response to the positive emotion eliciting activities following writing about a sad experience, a second study in which participants choose which of the three activities they would like to do might help to determine if people with higher vagal control are more likely to use positive emotion eliciting activities to cope with feelings of sadness, as some literature might suggest.

Ultimately, understanding whether positive emotion eliciting activities are effective at promoting physiological, in addition to self-report, recovery from feelings of sadness is important in determining their value as a coping strategy for people dealing with the death of someone close. Some literature suggests that certain styles of coping can alleviate self-reported feelings of grief and sadness, but may negatively impact physiological arousal in ways that can be unhealthy over time (King, Taylor, Albright, & Haskell, 1990). Before determining whether the use of positive emotion eliciting activities should be advocated for coping with sadness, these relationships need to be more definitively explored.

Works Cited

Allen, J. J. B., Chambers, A.S., & Towers (2007). The many metrics of cardiac chronotropy: A pragmatic primer and a brief comparison of metrics. *Biological Psychology , 74*, 243-262.

Austin, M. A., Riniolo, T. C., Porges, S. W. (2007). Borderline personality disorder and emotion regulation: Insights from the polyvagal theory. *Brain and Cognition, 65*, 69-76.

Berntson, G. G., Cacioppo, J. T. & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychobiology, 30*, 183-196.

Bernston, G. G., Quigley, K. S., & Lozano, D. (2007). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Bernston (Eds.), *Handbook of Psychophysiology, 3rd Edition* (pp. 182-210). New York: Cambridge University Press.

Block, J., & Kremen, A. M. (1996). IQ and ego-resiliency: Conceptual and empirical connections and separateness. *Journal of Personality and Social Psychology, 70*, 349-361.

Bonanno, G. A., Colak, D. M., Keltner, D., Shiota, M. N., Papa, A., Noll, J. G… Trickett, P. K. (2007). Context matters: The benefits and costs of expressing positive emotion among survivors of childhood sexual abuse. *Emotion, 7*, 824-837. doi: 10.1037/1528-3542.7.4.824

Bradley, M. M., & Lang, P. J. (2007). Emotion and Motivation. In J. T. Cacioppo, L. G. Tassinary, & G. G. Bernston (Eds.), *Handbook of Psychophysiology, 3rd Edition* (pp. 581-607). New York: Cambridge University Press.

Brown, S., & Schwartz, G. E. (1980). Relationships between facial electromyography and subjective experience during affective imagery. *Biological Psychology, 11*, 49-62.

Chambers, A. S., & Allen, J. J. B. (2002). Vagal tone as an indicator of treatment response in major depression. *Psychophysiology, 39*, 861-864.

Ekman, P., Davidson, R. J., & Friesen, W. V. (1980). The Duchenne smile: Emotional expression and brain physiology II. *Journal of Personality and Social Psychology, 58*, 342-343.

Deutch, H. (1937). Absence of grief. *Psychoanalysis Quarterly, 6*, 12-22.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science, 11*(1), 86-89.

Fridlund, A. J., & Cacioppo, J. T. (1986). Guidelines for human electromyographic research. *Psychophysiology, 23*, 567-589.

Faschingbauer, T. (1981). *The Texas Inventory of Grief – Revised*, Houston, TX: Honeycomb publishing.

Falkenstern, M., Schiffrin, H. H., Nelson, S. K., Ford, L., & Keyser, C. (2009). Mood over matter: Can happiness be your undoing? *The Journal of Positive Psychology, 4*, 365-371.

Fredrickson, B. L. (1998). What good are positive emotions? *Review of General Psychology, 2*, 300-319.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The Broaden-and-Built theory of positive emotions. *American Psychologist, 56*, 218-226.

Fredrickson, B. L., & Branigan, C. A. (2005). Positive emotions broaden the scope of attention and thought-action repertoires. Cognition and Emotion, 19, 313-332.

Fredrickson, B. L., & Joiner, T. (2002). Positive emotions trigger upward spirals toward emotional well-being. *Psychological Science, 12*, 172-175.

Fredrickson, B. L., & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition and Emotion, 12*, 191-220.

Fredrickson, B. L., Mancuso, R. A., Branigan, C., & Tugade, M. (2000). The undoing effect of positive emotions. *Motivation and Emotion, 24*, 237-258.

Freud, S. (1957). Mourning and Melancholia. In. J Strachey (Ed. And Trans.), *The standard edition of the complete original works of Sigmund Freud* (Vol. 14, pp. 152-170) London: Hogarth Press. (Original work published in 1917).

Isen, A. M., Daubman, K. A., & Nowicki, G. P. (1987). Positive affect facilitates creative problem solving. *Journal of Personality and Social Psychology, 52*, 1122-1131.

King, A. C., Taylor, C., Albright, C. A., & Haskell, W. L. (1990). The relationship between repressive and defensive coping styles and blood pressure responses in healthy, middle-aged men and women. *Journal of Psychosomatic Research, 34,* 461-471.

Kok, B. E., & Fredrickson, B. L. (2010). Upward spirals of the heart: Autonomic flexibility, as indexed by vagal tone, reciprocally and prospectively predicts positive emotions and social connectedness. *Biological Psychology, 85,* 432-436. doi: 10.1016/j.biopsycho.2010.09.005

Kreibig, S. D., Wilhelm, F. H. M., Roth, W. T., & Gross, J. J. (2007). Cardiovascular, electrodermal, and respiratory response patterns to fear- and sadness-inducing films. *Psychophysiology, 44*, 787-806.

Lidstrøm, T. C. (2002). “It ain’t necessarily so”… Challenging mainstream thinking about bereavement. *Family and Community Healthy, 25*, 11-21.

Lyonsfeld, J. D., Borkovec, J. D., & Thayer, J. F. (1995). Vagal tone in generalized anxiety disorder and the effects of aversive imagery and worrisome thinking. *Behavior Therapy, 26*, 457.

Mancini, A. D., & Bonanno, G. A. (2009). Predictors and parameters of resilience to loss toward an individual differences model. *Journal of Personality, 77*, 1805-1831.

Mikulincer, M., & Florian, V. (1997). A cognitive-relational approach to emotions – The appraisal and coping components of sadness, shame, guilt, jealousy, and disgust. *Imagination, Cognition, and Personality, 16,* 263-279.

Movias, H. L., & Allen, J.J. B. (2005). Cardiac vagal tone, defensiveness, and motivational style. *Biological Psychology, 68,* 147-162.

O'Connor, M. F., Allen, J. J. B. & Kaszniak, A. W. (2002). Autonomic and emotion regulation in bereavement and depression. *Journal of Psychosomatic Research, 52*, 183-185.

O'Connor, M. F., Allen, J. J. B. & Kaszniak, A. W. (2005). Emotional disclosure for whom? A study of vagal tone in bereavement. *Biological Psychology, 68,* 135-146. doi: 10.1016/j.biopsycho.2004.04.003

Oveis, C., Cohen, A. B., Gruber, J., Shiota, M. N., Haidt, J., & Keltner, D. (2009). Resting respiratory sinus arrhythmia is associated with tonic positive emotionality. *Emotion, 9*(2), 265-270. doi: 10.1037/a0015383

Porges, S. W. (1995). Orienting in a defensive world: Mammalian modifications for our evolutionary heritage: A polyvagal theory. Psychophysiology, 32, 310-318.

Porges, S. W. (2007). The polyvagal perspective. *Biological Psychology, 74*, 116-143. doi: 10.1016/j.biopsycho.2006.06.009

Porges, S. W., Doussard-Roosevelt, J. A., Portales, A. L., & Greenspan, S. I. (1996). Infant regulation and the vagal "brake" predicts child behavior problems: A psychobiological model of social behavior. *Developmental Psychobiology, 29,* 697-712.

Raphael, B. (1983). *The Anatomy of Bereavement*. New York: Basic Books.

Ray, R. D., McRae, K., Ochsner, K. N., & Gross, J. J. (2010). Cognitive reappraisal of negative affect: Converging evidence from EMG and self-report. *Emotion, 10*(4), 587-592. doi: 10.1037/a0019015

Sanders, C. M. (1993). Risk factors in bereavement outcome. In M. S. Stroebe, W. Stroebe, & R. O. Hansson (Eds.), *Handbook of Bereavement: Theory, Research, and Intervention.* Cambridge, U.K.: Cambridge University Press.

Soenke, M., Greenberg, J. & O'Connor, M.F. (in preparation). Using positive emotion eliciting activities to cope with sadness: Perceptions and reality.

Souza, G. G. L., Mendonca-da-Souza, A. C. F., Barros, E. M., Coutinho, E. F. S., Oliveira, L., Mendlowicz, M. V… Volchan, E. (2007). Resilience and vagal tone predict cardiac recovery from acute social stress. *Stress, 10*(4), 368-374. doi: 10.1080/10253890701419886

Tugade, M. M., & Fredrickson, B. L. (2004). Resilient individuals use positive emotions to bounce back from negative emotional experiences. *Journal of Personality and Social Psychology, 86*, 320-333.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*, 1063-1070.

Table 1

Mean Difference for Emotions in Response to the Coping Activities Minus Baseline

		Mean		Standard Deviation	
Type of Activity		Sadness	Neutral	Sadness	Neutral
Positive Emotion Eliciting	Sadness	-1.57	-0.39	1.29	1.14
	Positive Emotion	0.33	1.79	1.80	8.62
	Guilt	-0.19	-0.42	0.51	1.01
Neutral	Sadness	-2.00	-0.29	1.73	0.69
	Positive Emotion	1.00	-0.12	2.00	0.99
	Guilt	-1.05	-0.29	1.54	0.69
Grief Work	Sadness	0.25	0.50	1.18	1.02
	Positive Emotion	-0.13	-2.07	0.81	2.02
	Guilt	-0.44	0.07	1.15	0.73

Table 2

Corrugator Activity (Z scores) for Emotion Condition by Time

	Mean				Standard Deviation			
	Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Sad	-0.44	0.58	0.49	-0.57	0.78	0.63	0.71	0.65
Neutral	-0.30	0.10	0.79	-0.52	0.78	0.76	0.73	0.56

Table 3

Corrugator Activity (Z scores) for Type of Activity by Time

	Mean				Standard Deviation			
	Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Funny	-0.31	0.42	0.45	-0.47	0.56	0.83	0.74	0.74
Neutral	-0.27	0.38	0.52	-0.62	0.90	0.79	0.79	0.50
Grief Work	-0.58	0.23	0.99	-0.56	0.83	0.53	0.52	0.54

Table 4

Corrugator Activity (Z scores) for Emotion Condition by Activity by Time

		Mean				Standard Deviation			
		Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Sad	Funny	-0.52	0.63	0.38	-0.49	0.56	0.80	0.62	0.85
	Neutral	-0.25	0.69	0.29	-0.72	0.90	0.59	0.79	0.39
	Grief Work	-0.61	0.38	0.87	-0.48	0.83	0.43	0.59	0.64
Neutral	Funny	-0.10	0.20	0.52	-0.44	0.90	0.82	0.87	0.64
	Neutral	-0.30	0.00	0.80	-0.50	0.76	0.85	0.72	0.60
	Grief Work	-0.55	0.07	1.12	-0.65	0.63	0.59	0.41	0.42

Table 5

Zygomaticus Major Activity (Z scores) for Type of Activity by Time

	Mean				Standard Deviation			
	Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Funny	0.25	-0.15	0.27	-0.04	0.86	0.78	1.01	0.81
Neutral	1.92	0.28	-0.02	-0.29	0.99	0.81	0.83	0.75
Grief Work	-0.50	0.18	-0.09	0.42	0.79	0.84	0.91	0.67

Table 6

Zygomaticus Major Activity (Z scores) for Emotion Condition by Activity by Time

		Mean				Standard Deviation			
		Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Sad	Funny	0.67	-0.19	0.17	-0.49	0.92	0.69	1.04	0.85
	Neutral	0.27	0.10	0.12	-0.72	0.96	0.85	0.86	0.39
	Grief Work	-0.55	0.31	0.07	-0.48	0.86	0.81	0.96	0.64
Neutral	Funny	-0.02	-0.11	0.37	-0.44	0.83	0.89	0.99	0.64
	Neutral	0.11	0.49	-0.20	-0.50	1.05	0.72	0.78	0.60
	Grief Work	-0.45	0.05	-0.25	-0.65	0.74	0.88	0.87	0.42

Table 7

Orbicularis Oculi Activity (Z scores) for Emotion Condition by Activity by Time

		Mean				Standard Deviation			
		Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Sad	Funny	-0.33	0.18	0.42	-0.28	0.98	0.71	0.86	0.71
	Neutral	-0.30	0.48	0.32	-0.49	0.86	0.72	0.79	1.04
	Grief Work	-0.22	0.16	0.64	-0.60	0.94	0.80	0.74	0.82
Neutral	Funny	-0.01	-0.06	0.40	-0.31	0.78	0.75	1.15	0.71
	Neutral	-0.04	0.63	-0.06	-0.50	0.73	0.49	0.82	0.89
	Grief Work	-0.53	0.25	0.04	0.25	0.84	0.73	0.94	0.79

Table 8

Mean HR for Condition by Type of Activity

		Mean	Standard Deviation
Sad	Funny	78.59	25.36
	Neutral	87.81	26.81
	Grief Work	77.09	27.64
Neutral	Funny	80.68	26.81
	Neutral	76.07	27.64
	Grief Work	75.37	29.54

Table 9

Mean HR for Condition by Activity by Time

		Mean				Standard Deviation			
		Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Sad	Funny	78.43	81.33	77.04	77.53	13.71	13.41	12.37	12.71
	Neutral	87.10	89.83	87.63	86.67	11.96	9.20	10.45	10.15
	Grief Work	76.92	79.90	74.72	76.84	11.94	12.82	12.24	11.61
Neutral	Funny	79.71	82.85	79.85	80.32	12.19	10.61	10.28	10.51
	Neutral	75.50	79.13	74.87	74.77	12.30	12.34	11.56	12.32
	Grief Work	75.08	77.70	73.04	75.67	9.11	7.84	7.83	7.29

Table 10

Mean RSA for Condition by Time

		Mean	Standard Deviation
Sad	Funny	6.36	2.26
	Neutral	5.36	2.31
	Grief Work	6.02	2.39
Neutral	Funny	5.80	2.31
	Neutral	5.94	2.47
	Grief Work	6.49	2.55

Table 11

Mean RSA for Condition by Activity by Time

		Mean				Standard Deviation			
		Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Sad	Funny	6.47	5.78	6.63	6.56	1.01	1.27	1.10	0.99
	Neutral	5.50	5.03	5.44	5.48	1.05	0.91	0.94	0.95
	Grief Work	6.23	5.57	5.80	6.24	1.12	1.19	1.16	1.10
Neutral	Funny	5.99	5.34	5.94	5.93	1.17	0.84	0.95	0.80
	Neutral	6.05	5.03	6.20	6.14	1.35	1.22	1.42	1.27
	Grief Work	6.62	5.57	6.82	6.43	0.75	0.63	0.69	0.70

Table 12

Mean HR for Vagal Control by Time

	Mean				Standard Deviation			
	Baseline	Emotion Induction	Activity	Recovery Period	Baseline	Emotion Induction	Activity	Recovery Period
Low	85.55	87.20	83.62	84.45	15.75	15.59	14.41	14.58
High	72.59	76.71	72.45	72.95	15.00	14.86	13.72	13.88

Table 13

Mean HR for Vagal Control by Condition by Type of Activity

			Mean	Standard Deviation
Low	Sad	Funny	88.93	34.96
		Neutral	88.77	25.66
		Grief Work	83.46	30.83
	Neutral	Funny	86.75	30.83
		Neutral	84.50	32.71
		Grief Work	78.80	53.41
High	Sad	Funny	72.55	26.71
		Neutral	84.68	46.26
		Grief Work	68.90	34.96
	Neutral	Funny	73.86	32.71
		Neutral	67.64	32.71
		Grief Work	74.44	27.89

Figure 1: Mean Difference for Sadness in Response to the Coping Activities Minus Baseline

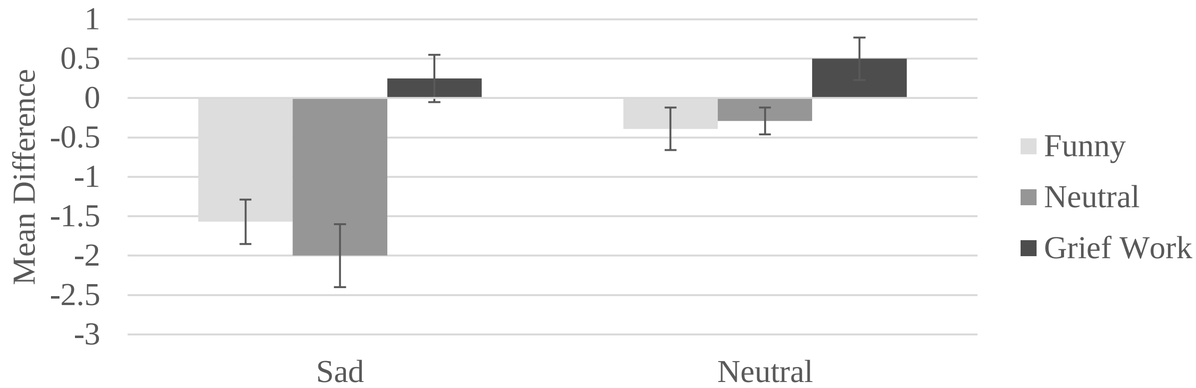


Figure 2: Mean Difference for Positive Emotion in Response to the Coping Activities Minus Baseline

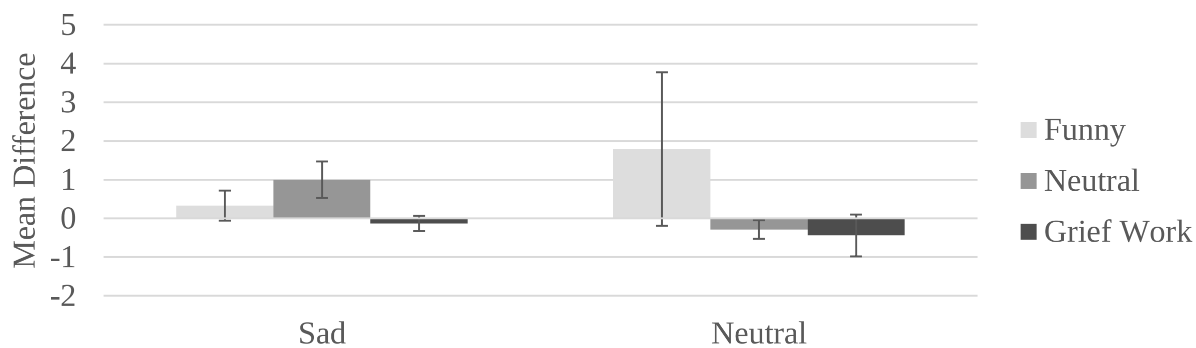


Figure 3:Mean Difference for Guilt in Response to the Coping Activities Minus Baseline

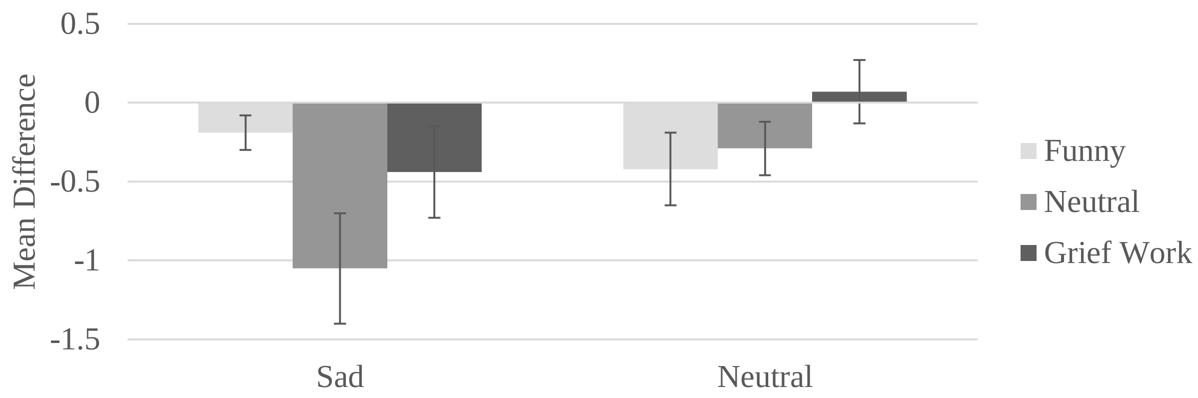


Figure 4: Corrugator Activity (Z scores) for Emotion Condition by Time

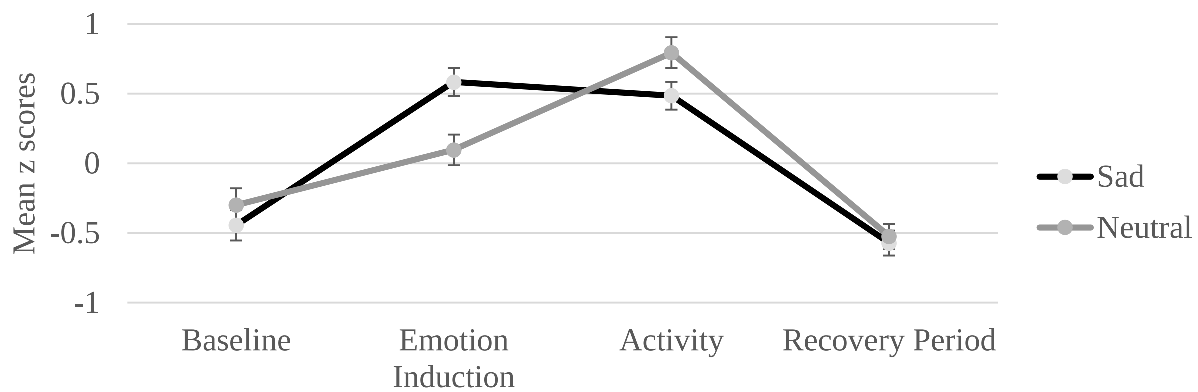


Figure 5: Corrugator Activity (Z scores) for Type of Activity by Time

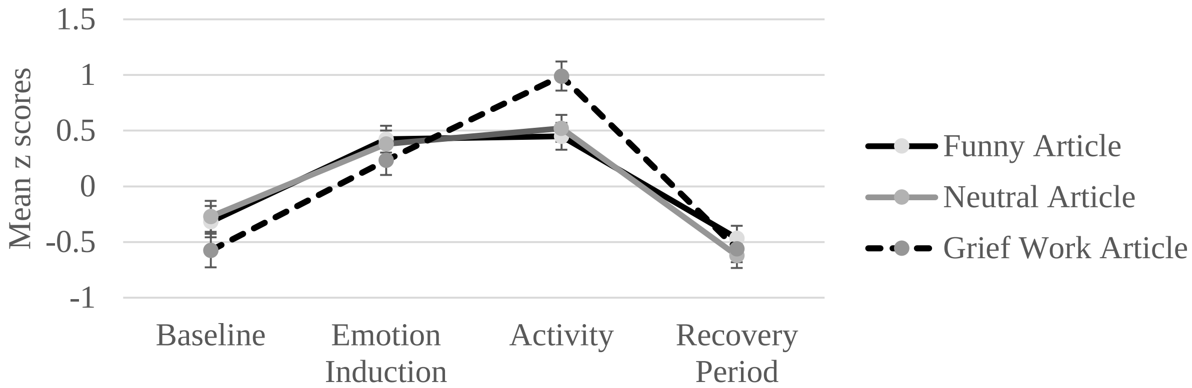
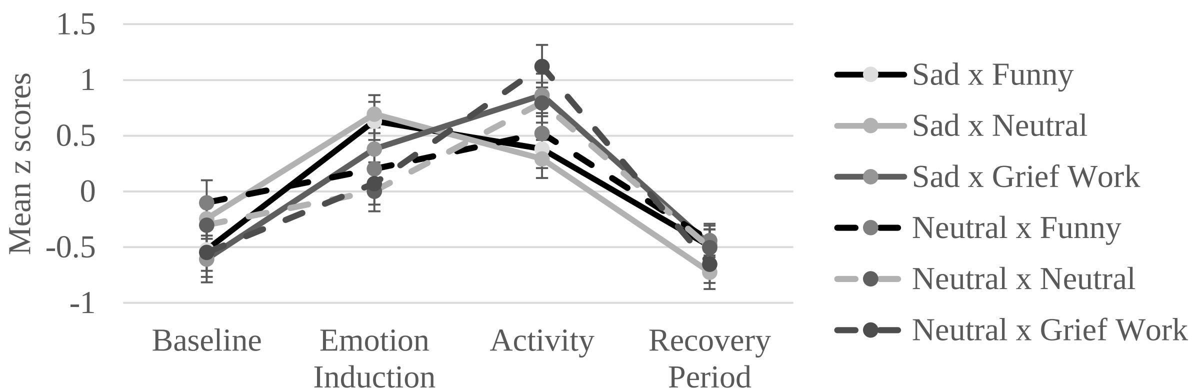


Figure 6: Corrugator Activity (Z scores) for Emotion Condition by Type of Activity by Time



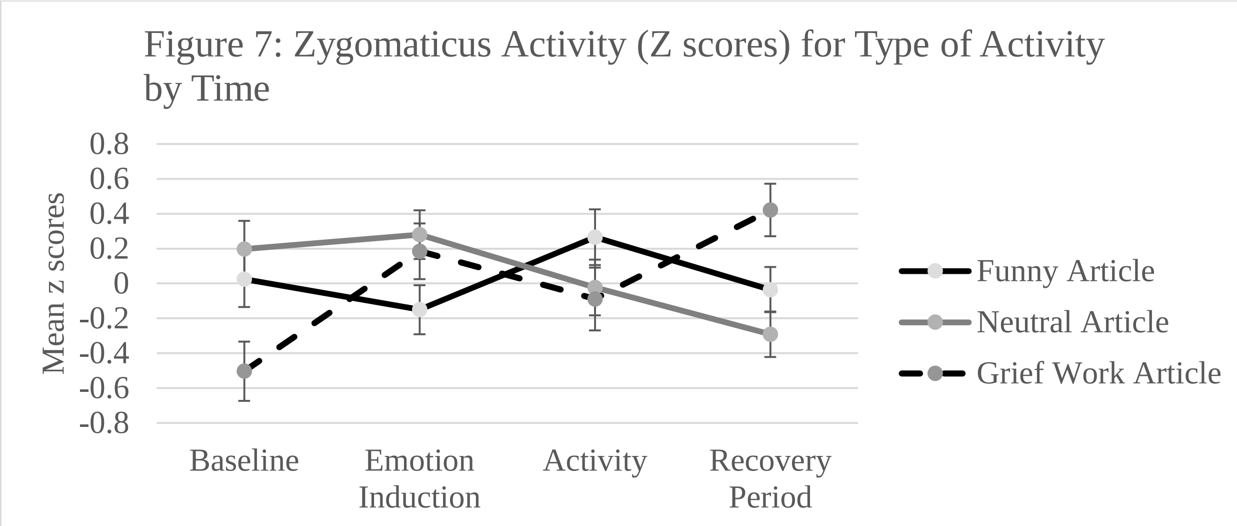


Figure 7: Zygomaticus Activity (Z scores) for Type of Activity by Time
Mean z scores
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Baseline
Emotion Induction
Activity
Recovery Period
Funny Article
Neutral Article
Grief Work Article

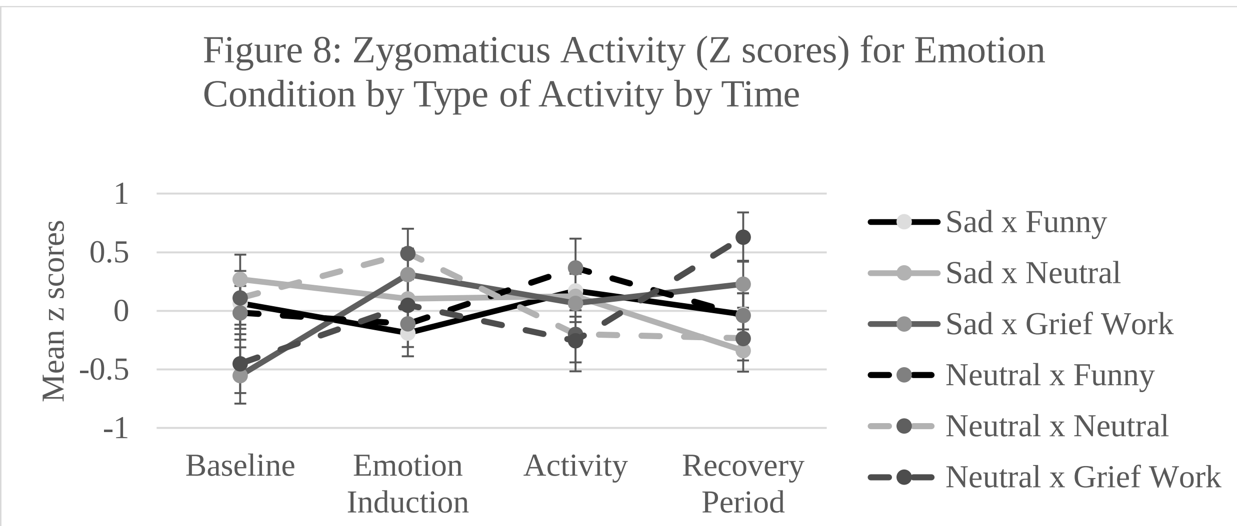


Figure 8: Zygomaticus Activity (Z scores) for Emotion Condition by Type of Activity by Time
Mean z scores
1
0.5
0
-0.5
-1
Baseline
Emotion Induction
Activity
Recovery Period
Sad x Funny
Sad x Neutral
Sad x Grief Work
Neutral x Funny
Neutral x Neutral
Neutral x Grief Work

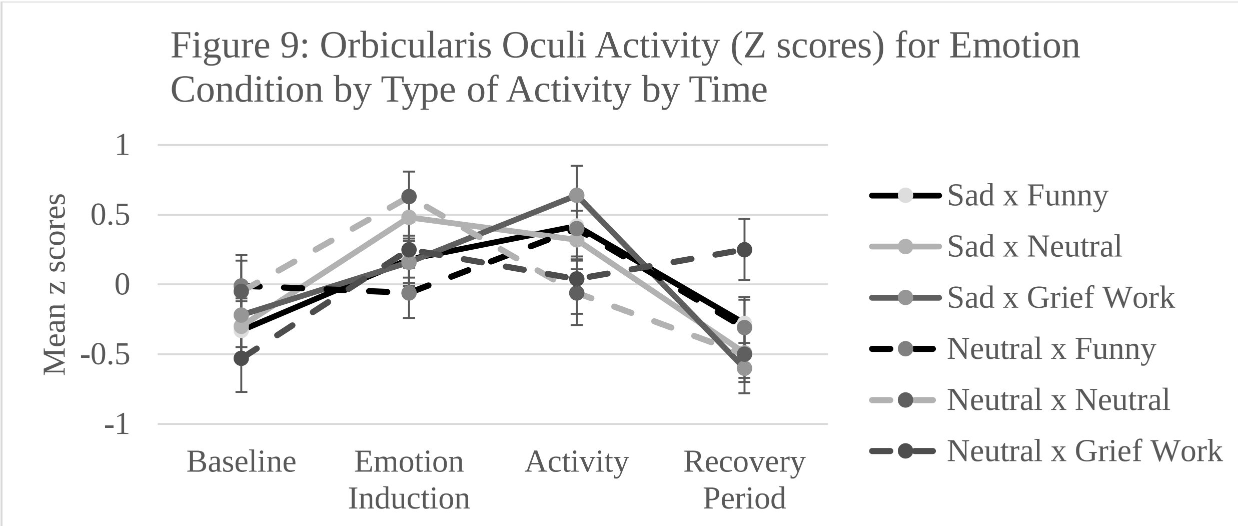


Figure 9: Orbicularis Oculi Activity (Z scores) for Emotion Condition by Type of Activity by Time
Mean z scores
1
0.5
0
-0.5
-1
Baseline
Emotion Induction
Activity
Recovery Period
Sad x Funny
Sad x Neutral
Sad x Grief Work
Neutral x Funny
Neutral x Neutral
Neutral x Grief Work

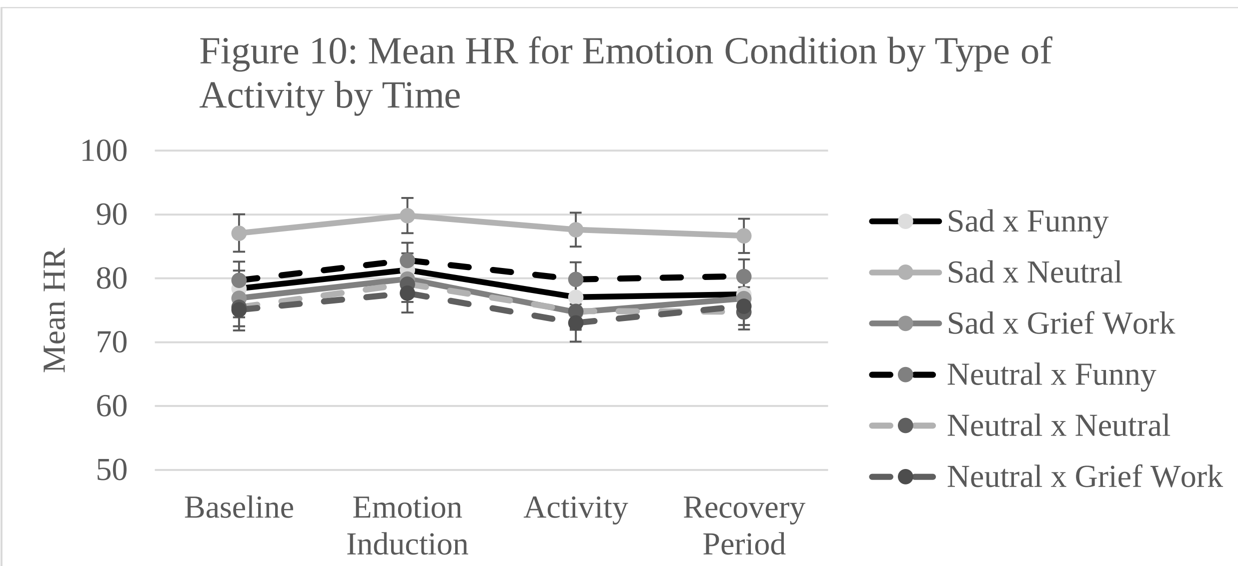


Figure 10: Mean HR for Emotion Condition by Type of Activity by Time
Mean HR
100
90
80
70
60
50
Baseline
Emotion Induction
Activity
Recovery Period
Sad x Funny
Sad x Neutral
Sad x Grief Work
Neutral x Funny
Neutral x Neutral
Neutral x Grief Work

Figure 11: Mean RSA for Emotion Condition by Type of Activity by Time

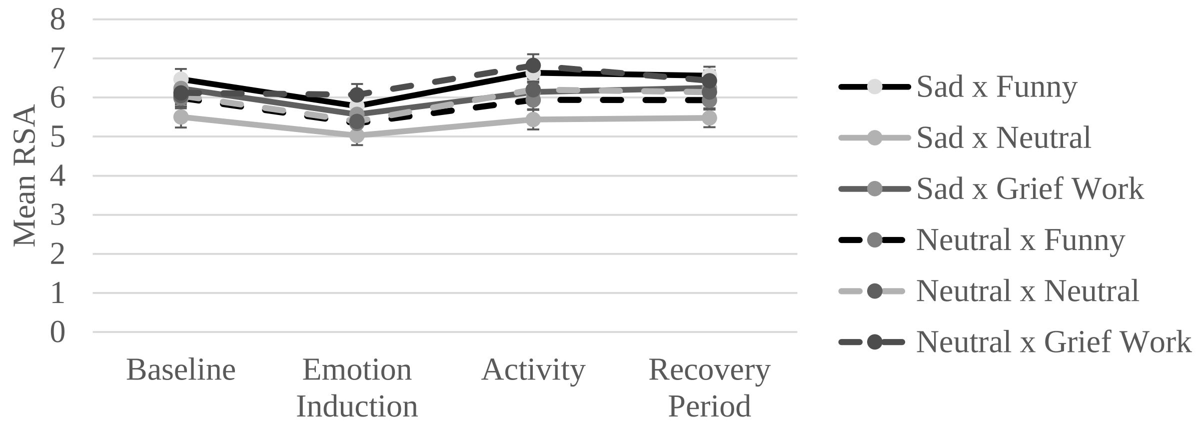


Figure 12: Mean HR for Vagal Control by Time