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THE EFFECTS OF RUMINATION AND WORRY ON CONTRAST AVOIDANCE IN

MAJOR DEPRESSIVE DISORDER AND GENERALIZED ANXIETY DISORDER:

AN APPLICATION OF CONTRAST AVOIDANCE MODEL OF WORRY

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ABSTRACT

Recent theories have suggested that both rumination and worry may facilitate emotional contrast avoidance in major depressive disorder (MDD) and generalized anxiety disorder (GAD). However, rumination and worry have never been compared in this regard. Therefore, this study aims to compare worry and rumination within the framework of the contrast avoidance model. Participants were selected based on BDI-II and GAD-Q-IV. Participants with high MDD, high GAD and low MDD & GAD controls were randomly assigned to engage in either rumination, worry or relaxation. In each condition, all participants were exposed to three emotion-inducing video clips designed to arouse sadness, fear and amusement. During the process, subjective emotionality and heart rate variability was measured. Results from multilevel modeling showed that rumination induction attenuated a sudden increase of sadness during sad follow-up video exposure. Similar to findings from a previous study, worry induction also attenuated abrupt increase of fear during the fear video exposure. However, such specificity was not found in amusement in response to amusement video exposure. Analysis of the group-by-induction condition interaction showed that the GAD group reported worry as more helpful in coping during the negative video exposure than the control group. However, rumination was linked to greater coping with sadness, regardless of group differences. Heart rate variability analysis revealed that worry was more closely related to cardiac defensive reactivity than rumination. RSA score in rumination was inconsistent across different trials. Nonetheless, compared to the control group, the GAD group reported the greatest comfort with sustained negative emotion, suggesting a greater tendency toward contrast avoidance. In addition, results showed that the reactivity of rumination and worry was nuanced by the type of stressor. In this study, rumination

showed more reactivity to sadness, and worry was more reactive to fear. These results indicate that there is convergence and divergence of rumination and worry. Although rumination and worry share a similar emotion processing mechanism, results of this study show that presentation of their emotional response can vary based on the type of emotions. Based on these results, we discuss clinical implications and limitations of this study.

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I dedicate this thesis to the three women in my life: to my mother, Seok Hee Seo, of blessed memory; to my loving wife, Ga Young Lee; and to my newborn daughter, Yuha Kim.

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Chapter 1. Introduction

Previous studies have suggested that people with major depressive disorder (MDD) often experience perseverative feelings of hopelessness, helplessness, self-depreciation, worthlessness, and inappropriate guilt (Beck, 1964; Kovacs & Beck, 1978; Pyszczynski & Greenberg, 1987). The most widely accepted concept that describes these recurrent thoughts is Nolen-Hoeksema's definition of depressive rumination. According to Nolen-Hoeksema (1991), rumination is defined as "behaviors and thoughts that passively focus one's attention on one's depressive symptoms and on the implications of these symptoms." Nolen-Hoeksema proposed that rumination serves as the main risk factor for depressive symptoms and that it is distinct from typical cognitive mechanisms found in healthier populations and from symptoms found in other diagnostic disorders (Nolen-Hoeksema, 1991).

In support of Nolen-Hoeksema's theory, studies have found that ruminative response to dysphoric mood serves as a vulnerability factor in the development and maintenance of MDD (Just & Alloy, 1997; Nolen-Hoeksema, 2000, 1998; Nolen-Hoeksema, Morrow, & Fredrickson, 1993). Furthermore, the predominant cognitive process of those with MDD and dysphoric mood is negative perseveration (Watkins, Teasdale, & Williams, 2000; Watkins, Moulds, & Mackintosh, 2005). Rumination also intensifies (Nolen-Hoeksema, 2000; Nolen-Hoeksema & Morrow, 1993) and prolongs the duration of episodes of depressed mood (Nolen-Hoeksema et al., 1993). More recent experimental studies also have suggested that rumination may be related to increased levels of systolic blood pressure and is an indicator of activation of the autonomic nervous system (Vickers & Vogeltanz-Holm, 2003). In another experimental study conducted by Sigmon et al. (2000), a rumination induction was positively correlated with increased levels of

skin conductance in female participants who were high in anxiety sensitivity. Although there have been very limited number of studies which examined the relationship between rumination and cardiac activity, studies have shown that rumination may be related to sustained and recurring elevations of blood pressure (Glynn, Christenfeld, & Gerin, 2002) and may be associated with increased heart rate (Thayer & Lane, 2002). Considering that rumination involves not only emotional but also physiological processing, having a more integrative understanding of these different domains is also important.

A related line of research has focused on another type of perseverative thinking, worry, which is similar to rumination. As rumination is conceptualized as the core mechanism of MDD, worry is considered to be the cardinal feature of generalized anxiety disorder (GAD; American Psychiatric Association, 1994). What is thought to distinguish worry from rumination is the temporal orientation of negative thinking. Whereas rumination is conceptualized as repetitive thought about past mistakes and failures, worry is defined as intrusive thoughts and images about anticipated future threats (Borkovec, Robinson, Pruzinsky, & DePree, 1983). Nonetheless, ample numbers of previous studies have suggested that worry and rumination may share common processes (Watkins et al., 2005). For example, rumination and worry may be generative of one another (McLaughlin, Borkovec, & Sibrava, 2007), and thus, may share similar mechanisms (Watkins & Moulds, 2007; Watkins et al., 2005). In support of this claim, Segerstrom and colleagues (2000) found strong positive correlations between rumination and worry in both clinical and non-clinical populations. In addition, they have found that a measure of repetitive thinking encompassed measures of rumination and worry as their latent variable. Furthermore, there is significant overlap between rumination, worry, and symptoms of depression and anxiety (McLaughlin, Borkovec, et al., 2007). Worry also occurs in depression (McLaughlin, Borkovec,

et al., 2007; Starcevic, 1995) and in turn, rumination is significantly associated with anxiety (Blagden & Craske, 1996; McLaughlin, Borkovec, et al., 2007).

One potential mechanism that may be similar across worry and rumination might be found in the Contrast Avoidance Theory proposed by Newman and Llera (2011). According to this model, a benefit of chronic worry is to sustain negative emotional valence as a means to avoid experiencing a sharp negative emotional shift (or negative emotional contrast). Empirical data in fact showed that individuals with GAD were more sensitive to negative emotional contrasts than a non-anxious control group and they viewed perseverative thoughts as a defense against a sudden negative emotional experience (Llera & Newman, 2014). By assessing participants' absolute level of emotionality through baseline, worry inductions, and emotional exposures, these authors also found that worry heightened negative affect from baseline and it sustained negative emotionality across negative exposures. However, more euthymic states such as a relaxation induction increased the experience of an acute shift of emotionality in a negative direction, in response to negative emotional exposures. In addition, those with GAD reported that they preferred worrying to cope with this shift whereas non-anxious controls preferred relaxation (Llera & Newman, 2014, 2010a).

Similar to GAD, there is some evidence that Contrast Avoidance may be operating in MDD. For example, the more people with depression were prone to ruminate, the more likely they were to have positive beliefs about rumination (Papageorgiou & Wells, 2003; Watkins & Moulds, 2005). In addition, Nolen-Hoeksema and Morrow (1993) found that rather than muffle their dysphoric mood, rumination induction led participants to become significantly more dysphoric. Moreover, dysphoric individuals were prone to sustain ruminative self-focus and this tendency was correlated with sustained negative emotional experience in daily life (Moberly &

Watkins, 2008). Similarly, in a laboratory study comparing experimentally induced worry and rumination in an unselected sample (McLaughlin, Borkovec, et al., 2007), both rumination and worry inductions caused increased negative emotionality and decreased positive emotionality. Therefore, similar to the impact of worry, rumination may be used by depressed individuals to avoid a negative emotional contrast. In fact, a similar theory for rumination was posited by Nolen-Hoeksema and colleagues (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008).

Although rumination and worry have been perceived as having similar mechanisms in their cognitive and somatic processes, only one study has attempted to examine both emotional and physiological characteristics of both rumination and worry within the same study. Aldao, Mennin, and McLaughlin (2013) conducted an experimental study to examine overlapping and distinct features of rumination and worry with respect to cognitive and physiological mechanisms. However, this study only measured post levels of rumination, worry and heart rate variability in response to emotional exposure and did not take into account how prior levels of rumination and worry influenced later emotional and physiological responses. Furthermore, despite claims that rumination and worry may be homogeneous, depressive rumination has never been examined among people with GAD and worry has never been tested among people with MDD in a laboratory setting. In addition, although previous studies have shown that worry is strongly associated with reduced heart rate variability (Brosschot, Van Dijk, & Thayer, 2007; Fisher & Newman, 2013; Pieper, Brosschot, van der Leeden, & Thayer, 2010; Thayer, Friedman, Borkovec, Johnsen, & Molina, 2000), there have been only few studies that have examined the relationship between rumination and heart rate variability. Finally, since it is a fairly new model, the Contrast Avoidance Theory has never been tested within individuals who were high in major depression.

Therefore, the current study aimed to examine similarities and differences between rumination and worry in the maintenance of MDD and GAD and to expand on the Contrast Avoidance Model to explain emotional and physiological processes of rumination.

We propose four hypotheses. First, for both MDD and GAD, rumination and worry would lead to significant increases in negative emotional states as opposed to a relaxation induction. Also, compared to emotional states during baseline, rumination would lead to higher negative emotionality similar to findings for worry in the previous studies (Llera & Newman, 2014, 2010a; Newman, Llera, Erickson, Przeworski, & Castonguay, 2013; Newman, Llera, Erickson, & Przeworski, 2014).

Second, consistent with previous findings using worry (Llera & Newman, 2014, 2010a), both rumination and worry inductions would lead to sustained negative emotionality during negative emotional exposures. Heightened negative emotionality during rumination and worry inductions would attenuate a sharp shift in negative emotional experience during negative exposures whereas relaxation would not.

Third, we predict that these two patterns would be reflected in heart rate variability but only salient in worry induction condition. We predict that rumination would present little or no impacts on the heart rate variability. Previous studies have shown mixed results for rumination. Only one study showed that rumination decreased heart rate variability (Ottaviani, Shapiro, Davydov, Goldstein, & Mills, 2009) and the other studies showed no relationship between HRV and trait and state rumination (Aldao et al., 2013; Key, Campbell, Bacon, & Gerin, 2008). These equivocal results were contributed by the weaker association between rumination and heart rate variability. For heart rate variability, we measured respiratory sinus arrhythmia (RSA), which is an index of parasympathetic cardiac outflow accounting for interference of respiration

(Grossman, Stemmler, & Meinhardt, 1990). As found in previous evidences, rumination and worry would lead to decreased heart rate variability. In addition, similar to the emotion processing, the decreased level of heart rate variability would be followed by sustained increase in heart rate variability during negative exposure.

Fourth, as was found for GAD (Llera & Newman, 2014, 2010a), those with depression would experience a prior ruminative induction as more helpful in managing aversive emotional experience during negative film clip exposures than would the non-depressed control groups.

Chapter 2. Methods

Study Design

The current study had a three (rumination vs. worry vs. or relaxation induction) by three (MDD vs. GAD vs. Non-MDD/GAD controls) design to examine the differential effects of each emotion induction on exposure to three different emotional video stimuli (sadness, fear, amusement) across individuals with MDD, GAD and non-MDD & GAD controls.

Participants

191 participants (154 females; M_{age} = 18.60 years, SD = 1.55years) were recruited from introductory psychology courses at a state university located in a semi-rural area (see Table 1). Ethnic distribution of participants was 72.77% Caucasian, 10.47% Asian, 6.28% Latino(a), 6.28% African American, 4.19% other.

Participants were given two research credits for their participation in this study. In order to screen participants, the Beck Depression Inventory-II (Beck, Steer, & Brown, 1996b) and the

Generalized Anxiety Disorder Questionnaire-IV (GAD-Q-IV; Newman et al., 2002) were

administered during recruitment process. Participants were assigned to the MDD group if their

scores on the BDI were above 29 but their GAD-Q-IV score did not meet the diagnostic cutoff of

GAD. Participants assigned to the GAD group were people whose GAD-Q-IV scores were above

the diagnostic cutoff but their BDI-II scores were lower than 14. Those in the non-MDD and

GAD control group were individuals whose scores on the BDI-II were lower than 14 and whose

GAD-Q-IV scores did not meet the diagnostic cutoff for diagnosis of GAD. In this study, 54

MDD participants, 51 GAD participants, and 86 control participants were recruited (see Table 1).

Among them, 59 participants engaged in rumination induction, 71 participants engaged in worry

induction, and 61 participants were assigned to relaxation induction condition.

Screening Measures

Beck Depressive Inventory II (BDI-II)

The BDI-II is a 21 item self-report instrument for severity of depressive symptoms, in

psychiatrically diagnosed persons above age 12 (Beck, Steer, & Brown, 1996a). It has

demonstrated internal consistency among college students (Cronbach's $\alpha = .93$) and among

outpatients (Cronbach's $\alpha = .92$) (Beck et al., 1996a). Retest reliability has been good ($r = .93$)

(Beck et al., 1996a; Sprinkle et al., 2002). The scale also has good factorial structure and

convergent and discriminant validity(Beck et al., 1996a; Steer, Ball, & Ranieri, 1999). Each item

has a 4-point Likert scale, ranging from 0 (none depressive symptom) to 3 (severe depressive

symptom) yielding total scores ranging from 0 to 63. Scores of 14 or higher are suggestive of a

clinically significant level of dysphoria. In this study, persons with a BDI-II score of 29 (severe

range) but who did not meet the diagnostic cutoff on the GAD-Q-IV were screened in as the MDD group.

Generalized Anxiety Disorder Questionnaire for DSM-IV (GAD-Q-IV)

This is a 9-item self-report measure developed by Newman et al. (2002). It has yes-no items measuring excessiveness and uncontrollability of worry (e.g., "Do you experience excessive worry?") and associated physiological symptoms (e.g., muscle tension). An open-response item asks for a list of the most frequent worrisome topics. Two items are dimensional, ranging from 0 (no symptoms) to 8 (very severe symptoms) and measure functional impairment and subjective distress. It has good internal consistency (Cronbach's α = .94). In addition, it demonstrated stable 2-week retest reliability (r = .81) and good convergent and discriminant validity. Furthermore, strong interrater agreement with a semi-structured diagnostic interview was found (Cohen's k=.67) (Newman et al., 2002). In this study, individuals who met diagnostic criteria for GAD but scored low on the BDI-II (lower than 14) were assigned to the GAD group.

Manipulation Check Measures

In order to assess the effectiveness of rumination, worry and relaxation inductions, a manipulation check was administered immediately after each induction task. Each measure consisted of four 9-point Likert scales ranging from 0 (e.g., "not at all") to 8 (e.g., "definitely") and was adapted from the one used in Llera and Newman (2014).

Self-Report Emotion Measures

For consistency with previous studies (Llera & Newman, 2014, 2010a), we used self-reported emotion measures used in the previous study. These questionnaires were a combination

of three different emotion questions first used in Gross and Levenson (1995) and these include amusement, fear and sadness. Each item was assessed on a 9-point Likert scales ranging from 0 (not at all) to 8 (extremely).

Contrast Avoidance Questionnaire

In order to measure the extent to which each of rumination, worry and relaxation inductions help participants facilitated emotional coping during the exposure to each emotion eliciting film clip, we adapted a measure that was used in previous studies (Llera & Newman, 2014). This measure was developed based on the Why Worry Scale-II (Gosselin et al., 2003). The questionnaire consists of six items asking about the extent to which the induction tasks contributed to coping with emotionality that occurred during exposure to film clips. Based on a 9-point Likert scale ranging from 0 (not at all true) to 8 (absolutely true), participants rated the effects of each of their assigned induction tasks on coping with emotions elicited in the video exposure. Three items measured the extent to which emotion elicited in the induction period facilitated emotional coping during the film exposure (i.e., "feeling less [emotion] by negative/positive events in the film clips") and the other three reverse-coded items assessed the opposite effect (i.e., "feeling more [emotion] by positive/negative events in the film clips"). Higher scores in the contrast avoidance measure suggest that participants perceived the induction to be more helpful in coping with emotional exposures and lower scores indicate that the induction was not helpful in coping with emotional exposures. Among the six items, one of the reverse-scored items was removed in the analysis of the previous study due to its low item-total correlation, leaving five total items. The internal consistency of the five total items were reliable (Cronbach's $\alpha =.73$) and item-total correlations of each single item also indicated reliability

ranging from .57 to .74 ($p < .001$ for all items). The measure also showed significant convergent

validity with the GAD-Q-IV ($r = .49$, $p < .001$) and Penn State Worry Questionnaire ($r = .49$, p

$< .001$) (Llera & Newman, 2014).

In this study, we adapted the five items used in the previous study. Using each of the five

items as a format, we created each set of three items which measure participants' copings with

amusement, fear and sad exposures in each of the three inductions. Results from internal

consistency analysis indicated that one format of the items had enough reliability across different

types of inductions and exposures (Cronbach's $\alpha = .76$) (i.e., "Because I already felt bad from

[induction type], it was less of a shock to feel a sense of [emotion type] from the film clip."). In

this study, we included items of this format in our final analysis.

Physiological Measure

Along with subjective reports of emotion, each participant's physiological responses

were recorded continuously using Biopac MP150 (Biopac Systems, Inc., Goleta, CA) at a

sampling rate of 5,000 Hz. For the assessment of RSA, participants' heart rate and respiration

were measured by Ag/AgCl gelled ECG electrodes and RSP transducer belt. RSP data was

calculated based on the RR interval detection method and analyzed by Acqknowledge 4.1

software.

Emotion-Eliciting Stimuli

For elicitation of sadness, fear and amusement, we used standardized film stimuli

developed by Gross and Levenson (1995). In this study, three video clips were used for

emotional exposure. For elicitation of sadness, "The Champ" was be presented for 171s and in

this scene participants watched as a boy cries at his father's unexpected death. For fear, they watched the 82s clip from "The Shining", in which a boy sees twins in the hallway. For amusement, participants watched the 155s clip of fake orgasm scene from "When Harry Met Sally". In this study, the three emotional film stimuli were presented in a counterbalancing order. Self-reported emotion was measured after each of these clips and was followed by a distraction video clip. The distraction video clip was part of the documentary movie, "Alaska's Wild Denali" which depicts the natural beauty of Alaska and this clip was played for 80s. In the previous validation study which assessed subjective emotionality across three different emotions, each clip was reported to be effective in eliciting target emotional states (Gross & Levenson, 1995).

Induction Tasks

Depending on their experimental condition, participants engaged in one of the three different induction tasks: rumination, worry or relaxation. Previous research showed that an induction task using a series of questions (e.g., "Think about the physical sensations you feel in your body", "Think about your character and who you strive to be", "Think about the degree of clarity in your thinking right now." etc.) has been more frequently used in the study of rumination and a personally relevant self-guided induction task (e.g., asking people to worry or ruminate about something they are currently concerned about) has been more widely used in the study of worry. In order to control for the effects of different induction methods and to make sure that each emotion-induction task elicited different target emotionality efficiently, we conducted a series of pilot studies comparing different types of emotion-induction tasks. The first method was adapted from Morrow and Nolen-Hoeksema (1990)'s previous experimental study. In this

condition, we asked participants to read a series of phrases that asked them to focus on various thoughts that were designed to evoke rumination or worry (e.g., "Think about whether you have accomplished a lot so far", "Think about the following: You will not be able to achieve your goals."). Contents of worrisome thoughts were adapted from the worry domain questionnaire (Tallis, Davey, & Bond, 1994).

The second method was adopted from (Borkovec & Inz, 1990)'s study (e.g., "Think about your most ruminative topic, in the way that you usually ruminate about it, but as intensely as you can", "Think about your most worrisome topic, in the way that you usually worry about it, but as intensely as you can."). As another part of the pilot study, we also compared the relaxation induction to the rumination and worry inductions in terms of the level of the elicited emotionality. In the relaxation condition, participants were asked to engage in the both progressive muscle relaxation and diaphragmatic breathing for 10 minutes. Guided instructions for the relaxation induction were recorded by a professional voice artist and an ambient background music was added. After giving participants definitions of either rumination, worry, or relaxation, they were instructed to engage in one of the three induction tasks. After engaging in each induction task, a manipulation check was administered to assess their effectiveness. Results of the pilot study indicated that the second method, which consisted of self-administered induction tasks, was more effective than the first method. Independent-samples t-test revealed that the both the self-administered rumination induction ($M = -3.08$, $SD = 10.43$) and self-administered worry induction ($M = -3.17$, $SD = 6.52$) produced significantly lower positive affect than the relaxation induction ($M = .38$, $SD = 6.09$) (rumination induction: $t(24) = -2.09$, $p = .047$; worry induction: $t(24) = -2.18$, $p = .039$). In addition, the self-administered rumination induction ($M = 8.46$, $SD = 9.86$) and worry induction ($M = 10.24$, $SD = 5.48$) yielded significantly higher

negative affect than the relaxation induction (M = -2.31, SD=3.97) (rumination induction: t (24)

= 3.65, p = .001; worry induction: t (24) = 4.28, p < .001). However, the first method, which

used the list of ruminative (M = 2.36, SD = 10.39) or worrisome phrases (M = -.34, SD = 8.78)

did not show a significant decrease in positive affect (rumination induction: t (25) = .60, p

= .553; worry induction: t (23) = -.64, p = .528). Ruminative phrases (M = -2.64, SD = 5.01) and

worrisome phrases (M = .79, SD = 9.35) also did not show significant increases in negative affect

compared to the relaxation induction (M = -2.31, SD=3.97) (rumination induction: t (25) = -.19, p

= .85; worry induction: t (23) = 1.08, p = .291). Based on these results, the non-phrase reading

self-administered induction task was administered in the current study for elicitation of both

rumination and worry.

Procedure

After consenting, participants were asked to complete a demographic questionnaire and

then washed their hands with non-abrasive soap. Next, they were hooked up to a

psychophysiology-monitoring device (using disposable pre-gelled ECG electrodes and a

respiration belt) and then seated in front of a computer monitor. All instructions and stimuli were

programmed by the E-prime experiment software and provided on the computer monitor in

order.

For 5-minutes, participants were asked to acclimate before beginning the experiment and

the final one minute was used as the initial baseline. After the 5-minute acclimation period, they

completed ratings of their subjective emotionality and a manipulation check measure. Next, they

were trained in one of three induction tasks and then engaged in one of the self-administered

induction tasks for two (rumination and worry induction) or ten minutes (relaxation induction).

After the induction task, each participant's subjective emotion was assessed by a manipulation check measure. Then, they watched an emotion-eliciting video clip (these film clips were counterbalanced across participants to prevent order effects) and completed the same emotion measure, manipulation check measure and the Contrast Avoidance Questionnaire asking how rumination, worry or relaxation induction tasks affected their emotional coping during exposure to each video clip. Next, they watched a distraction video clip for 80 seconds in order to wash away the effects of the video clips. Before beginning the next block of the experiment, participants were asked to engage in the assigned induction task and proceed with the same procedure until all three emotion eliciting video clips (sadness, fear and amusement) were played. After completion of these three blocks, all the physiological devices were removed and participants were fully debriefed.

Data Analysis Methods

A multilevel modeling approach allows researchers to not only examine such variation across different populations, but also to test validity across higher level differences (Raudenbush & Bryk, 2002). In this study, multilevel modeling was used to understand change across the three different time points, when accounting for effects of individual, induction condition, and group differences. In the multilevel model, main and interaction effects across three different induction conditions, three different groups and two three different time trends were entered as fixed effects, and intercept was entered as random effects. For hypothesis 1 (i.e., rumination and worry would lead to increased negative emotional states), main and interaction effects of induction, group and time were tested based on the level of emotional state (i.e., sadness, fear, or amusement) at time 1 and time 2 (Baseline to Induction) as the dependent measures. For

hypothesis 2 (i.e., rumination and worry would attenuate a sharp increase of negative emotions during negative emotional exposure), main effects of induction on the level of affect were tested at time 2 and time 3 (Induction to Video exposure) and interactions between participant group (i.e., MDD, GAD, or Controls) were taken into account as well. For hypothesis 3 (i.e., Unlike worry, rumination would not attenuate a sharp decrease of heart rate variability and would not be less correlated with heart rate variability changes), main and interaction effects of induction, group and time were tested based on the RSA scores at different time trends. In order to test hypothesis 4 (i.e., MDD group would perceive rumination as more helpful in coping with negative emotional exposure than would the control group; MDD group would report relaxation as less helpful in coping with negative emotional exposure than would the control group), responses on the contrast avoidance scale were compared with the foci of main and interaction effects of induction task and group.

All statistical analyses were conducted using SPSS 22 software. To analyze differential effects of induction on emotional experience and physiological reactivity from baseline to video exposure, we examined the two trends of changes across time, which are scores from baseline to induction and induction to video exposure. On the significant results, we conducted simple slope analyses and follow-up Bonferroni post hoc tests in order to compare induction-specific change. A diagonal covariance matrix for repeated measures and random effects was provided for each model. In addition, using the same analytic approach, we examined participants' subjective reports on the emotional coping.

Chapter 3. Results

Descriptive Statistics and Baseline Emotions

Descriptive Statistics

Table 1 provides descriptive statistics for age, gender, BDI-II and GAD-Q-IV scores across three participant groups. There was no significant group difference in age, $F(2, 167) = 1.16$, $p = .315$ and gender of the participants, $F(2, 188) = .30$, $p = .740$. However, there were expected significant group differences in BDI-II scores, $F(2, 188) = 420.61$, $p < .001$, and GAD-Q-IV scores, $F(2, 188) = 327.15$, $p < .001$. Pairwise comparisons showed that participants in MDD had significantly greater levels of depression ($M = 25.39$, $SD = 6.22$) than the other two groups (GAD: $M = 8.47$, $SD = 2.90$; Control: $M = 3.91$, $SD = 3.54$), $F(2, 188) = 420.61$, $p < .001$. On the other hand, participants in GAD group reported significantly higher GAD-Q-IV scores ($M = 9.41$, $SD = 1.37$) than the other two groups (MDD: $M = 6.07$, $SD = 3.06$; Control group: $M = 1.20$, $SD = .87$), $F(2, 188) = 327.15$, $p < .001$. Unlike the MDD and GAD groups, the control group scored significantly lower on both BDI-II ($M = 3.91$, $SD = 3.54$), $F(2, 188) = 420.61$, $p < .001$ and GAD-Q-IV ($M = 1.20$, $SD = .87$), $F(2, 188) = 327.15$, $p < .001$. This shows that the screening criteria used in this study were effective in differentiating the three participant groups (see Table 1).

Baseline Emotions

At baseline, the three groups reported different levels of subjective emotionality. On baseline sadness, Bonferroni Post hoc analyses showed that the MDD group ($M = 1.15$, $SD = 1.60$) scored significantly higher sadness than the control group ($M = .19$, $SD = .64$) but they were not distinct from the GAD group ($M = .45$, $SD = .90$), $F(2, 188) = 13.90$, $p < .001$. In terms of fear, both the MDD ($M = .35$, $SD = 1.03$) and GAD ($M = .47$, $SD = .95$) groups reported greater levels of fear than control group ($M = .13$, $SD = .70$), $F(2, 188) = 2.72$, $p = .069$. On

baseline amusement, MDD group reported significantly lower amusement (M =.56, SD = 1.11)

than GAD group (M = 1.31, SD = 1.87). However, the control group (M = .95, SD = 1.54) was

not different from the MDD and GAD groups, F (2, 188) = 3.21, p = .042 (see Table 2).

Manipulation Check Scores

Induction Manipulation

In order to examine effectiveness of induction manipulation, we asked participants to rate

their levels of rumination, worry and relaxation on a 9-point Likert-type scale, ranging from 0

(not at all) to 8 (extremely). There were significant main effects of induction type, F (6, 3416) =

80.83, p < .001, η_p^2 = .12, and participant group, F (6, 3416) = 11.10, p < .001, η_p^2 = .02, as well

as a significant interaction between induction and participant group, F (12, 4519) = 1.92, p

= .027, η_p^2 = .004. Table 3 provides manipulation check scores in each induction condition and in

each participant group. Results of analysis of variance and Bonferroni post hoc test showed that

the rumination induction was more effective in eliciting rumination (M = 6.50, SE = .15) than

worry induction (M = 4.14, SE = .13) and relaxation induction (M = 1.39, SE = .14), F (2, 570) =

137.32, p < .001, η_p^2 = .14. Similarly, the worry induction was more effective in eliciting worry

(M = 5.58, SE = .12), than rumination induction (M = 3.88, SE = .14) and relaxation induction (M

= 1.47, SE = .13), F (2, 570) = 110.11, p < .001, η_p^2 = .11. Finally, the relaxation induction

effectively increased relaxation (M = 7.28, SE = .14) more than rumination induction (M = 3.04,

SE = .15) and worry induction (M = 2.82, SE = .14), F (2, 570) = 104.90, p < .001, η_p^2 = .11.

These results indicate that all three inductions were effective in eliciting their target emotions

(see Table 3).

On the other hand, there were also main effects of group. Bonferroni post hoc tests showed that both the MDD and GAD groups reported greater levels of rumination (MDD group: $M = 4.28$, $SE = .14$; GAD group: $M = 4.24$, $SE = .15$), $F (2, 570) = 18.53$, $p < .001$, $\eta_p^2 = .02$ and worry (MDD group: $M = 3.95$, $SE = .13$; GAD group: $M = 3.73$, $SE = .14$), $F (2, 570) = 22.73$, $p < .001$, $\eta_p^2 = .03$ than the control group (Ruminative: $M = 3.50$, $SE = .12$; Worried: $M = 3.24$, $SE = .11$). In terms of relaxation, the control group indicated significantly greater levels of relaxation ($M = 4.71$, $SE = .12$) than the other two groups (MDD group: $M = 4.29$, $SE = .15$; GAD group: $M = 4.13$, $SE = .16$), $F (2, 570) = 18.72$, $p < .001$, $\eta_p^2 = .02$ (see Table 3).

Furthermore, an interaction between the induction and group was marginally significant in levels of rumination, $F (4, 1719) = 2.02$, $p = .090$, $\eta_p^2 = .005$. In rumination induction, MDD group presented greater levels of rumination (MDD group: $M = 3.97$, $SE = .17$) than control group (Control group: $M = 3.46$, $SE = .13$). In worry induction condition, those in GAD group had greater levels of rumination (GAD group: $M = 3.13$, $SE = .16$) than control group (Control group: $M = 2.12$, $SE = .12$) while they were engaging in worry. However, even in the GAD group, levels of rumination were the highest in rumination induction condition ($M = 3.87$, $SE = .20$) than in worry induction ($M = 3.13$, $SE = .16$) and relaxation induction ($M = 1.56$, $SE = .15$). Thus, the rumination induction was still the most effective manipulation at eliciting a sense of rumination. There were no group differences in relaxation induction in terms of their levels of rumination. Based on these results, we judged that all three induction manipulations successfully elicited their target emotions.

Emotional Video Clips

In order to determine effectiveness of the emotional video clips, we also examined participants' emotional responses in each video exposure. There was a significant main effect of

exposure type, F (6, 1130) = 385.04, $p < .001$, $\eta_p^2 = .67$. Main effect of group and Interaction

between induction and group was not significant in this analysis. Bonferroni post-hoc test

showed that, regardless of the participant group, the sad video clip also significantly increased

sadness ($M = 6.01$, $SE = .15$) more than fear video ($M = 1.59$, $SE = .09$) and amusement ($M =$

1.19, $SE = .06$), F (2, 570) = 628.10, $p < .001$. The fear video clip also increased fear ($M = 4.66$,

$SE = .16$) significantly more than sad video ($M = 2.47$, $SE = .14$) and amusement video ($M =$

1.17, $SE = .05$), F (2, 570) = 203.36, $p < .001$. In addition, the amusement video clip also

increased a sense of amusement ($M = 6.31$, $SE = .16$) significantly more than sad video ($M =$

1.56, $SE = .09$) and fear video ($M = 2.40$, $SE = .13$), F (2, 570) = 391.79, $p < .001$. These results

indicate that all of the three exposure videos exclusively induced their target emotions (see Table

4).

Analyses of Hypotheses

Subjective Measures

In Table 5, we provided Multilevel Modeling statistics for each emotion in each

experimental condition. Subjective measures used in the analysis were the three target emotions

elicited from three video exposures (e.g., sadness in baseline, sadness in induction and sadness in

sad exposure).

Sadness: In the analysis of sadness, there was a significant interaction between induction

and time, F (4, 366) = 42.15, $p < .001$ (see Table 5). Simple slope analysis showed that

rumination and worry inductions increased levels of sadness from the baseline but relaxation did

not (see Table 6). Post hoc tests showed that increase in sadness from baseline to the rumination

induction, $\beta = .60$, t (117) = -8.17, $p < .001$, $d = 1.51$ was significantly greater than increase in

sadness in worry and relaxation inductions. The worry slope, β =.45, t (141) = -5.93, $p < .001$, d = 1.00, was also significantly steeper than relaxation slope, β =-.08, t (121) = .88, $p = .378$, $d =$ -.16 (see Table 7).

In terms of effects of induction on the sad film clip, interaction between induction and time was significant, F (4, 549) = 22.13, $p < .001$) (see Table 5). Simple slope analysis showed that all inductions led to increased sadness (see Table 6). However, slope comparison showed that among the three inductions, rumination led to less increased sadness than worry or relaxation (β =.29, t (117) = -3.25, $p < .001$, d = .60) (see Table 7). Furthermore, rumination was the only induction whose slope became significantly less steep from induction to the film clip exposure, t (232) = 2.94, $p = .003$ (see Table 8 & Figure 1).

Fear: In analyses of fear, results from baseline to induction indicated a significant interaction between induction and time F (4, 549) = 34.32, $p < .001$ (see Table 5). Rumination and worry increased fear from baseline (rumination: $\beta = .33$, t (117) = -3.76, $p < .001$, $d = .70$; worry: $\beta = .56$, t (141) = -8.00, $p < .001$, $d = 1.35$). Unlike rumination and worry, relaxation did not make any significant change, $\beta = -.06$, t (121) = .68, $p =.496$, $d = -.12$ (see Table 6). Furthermore, fear was increased more in response to the worry induction than in the rumination and relaxation inductions (see Table 7).

For fear, interaction between induction and time from induction to film clip was significant, F (4, 549) = 13.76, $p < .001$) (see Table 5). Although the fear clip increased fear from levels elicited during all inductions (see Table 6) the increase elicited by worry was significantly less steep than increases from the other two induction conditions, β =.20, t (141) = -2.46, $p < .05$, $d = .42$) (see Table 7). In addition, as can be seen in Table 8, comparison between baseline to induction slope and induction to exposure slope shows that unlike other inductions,

slope became significantly less steep after the worry induction, t (280) = 3.29, p = .001. This difference also can be observed in Figure 2, which presents differential changes in fear across the two different time trends.

Amusement: Results indicated a significant interaction between induction and baseline to induction time, F (4, 366) = 12.32, p < .001 (see Table 5). Simple slope analysis on each pair of the interactions showed that rumination and worry uniformly decreased amusement from baseline (rumination: β = -.36, t (117) = 4.13, p < .001, d = -.76; worry: β = -.36, t (141) = 4.51, p < .001, d = -.76). On the other hand, relaxation did not make any significant change from baseline to induction (β = .10, t (121) = -1.06, p =.291, d = .19). The three-way interaction between induction, time and group was not significant, F (8, 549) = 1.24, p =.295 (see Table 5).

In levels of amusement from induction to exposure, two-way interaction between induction and time was not significant, F (4, 366) = .21, p = .814. There was only significant three-way interaction between induction, time and group, F (8, 549) = 3.68, p = .007. Simple slope tests showed that the direction of the slopes was uniform across all induction types (see Table 6). Post hoc test also indicated that all three inductions were not distinct from each other (see Table 7). In addition, comparison between baseline to induction and induction to exposure slopes showed that regardless of induction type, all inductions led to a sharp increase in amusement (see Table 8 & Figure 3).

Heart Rate Variability

For heart rate variability analysis, natural-logged spectral-power value was used as an indicator of RSA for each epoch. The frequency of RSA was ranged from 0.24 to 1.04 Hz. Artifacts in RSA were cleaned based on computational and subjective methods. First, using a modified Pan and Tompkins algorithm (Pan & Tompkins, 1985), we detected QRS peak and

normalized cardiac interference. In addition, using the initially normalized data, we created R-R

tachogram graphs and these were cleaned by three undergraduate research assistants who had

extensive experience in physiological data cleaning. Subjectively detected artifacts were cleaned

using CardioEdit software (Center, 2007). Inter-rater reliability was 96.32% across all

physiological data.

Although there were no absolute RSA score differences at baseline, since changes in

RSA score were subtle across different types of induction tasks, we standardized the RSA data

by each induction condition using the mean and standard deviation of each baseline RSA score

as an anchor in order to examine within induction changes over time. Lower RSA score

implicates greater sympathetic influence (e.g., fight-or-flight) and higher RSA score indicates

greater parasympathetic reactivity.

Using the transformed data, we provided Multilevel Modeling statistics for RSA score in

Table 9. Then in table 10, we specified mean RSA scores at baseline, induction and exposure.

We also provided results from simple slope analysis in the adjoined columns. Table 11 and table

12 provide post hoc test results on the simple slopes. Table 11 compares slopes across different

induction types (Rumination vs. Worry vs. Relaxation) and Table 12 examines differences

between two different time trends (Baseline to Induction vs. Induction to Exposure).

Sad exposure: In sad exposure, none of the effects were significant on the baseline to

induction time trend, F (2, 150) = 1.49, p = .229 (see Table 9). Yet, simple slope analysis showed

that worry significantly decreased RSA score from the baseline, β = -.64, t (117) = -3.62, p

< .001, d = -.74. On this time trend, rumination, β = .05, t (113) = .09, p = .925, d = .02, and

relaxation, β = .22, t (121) = 1.35, p = .181, d = .03, were not significant (see Table 10). Post hoc

comparison showed that worry and relaxation were distinct from each other on the baseline to

induction time trend, t (210) = 3.57, p < .001. However, results showed that rumination and worry, t (194) = 1.21, p = .229, and rumination and relaxation, t (214) = .30, p = .764 were not different from each other (see Table 11).

In the mixed model on the induction to exposure time trend, interaction between induction and time was not found, F (2, 150) =.65, p = .525 (see Table 9). However, in the simple slope analysis, worry, β = .29, t (117) = 1.73, p = .087, d = .35, and relaxation, β = -.26, t (121) = -2.00, p = .048, d = -.37 yielded significant changes over time. In response to sad video exposure, worry significantly increased RSA score but relaxation significantly decreased RSA. On the other hand, rumination did not show any significant change over time, β = -.22, t (113) = -.42, p = .679, d = -.08 (see Table 10). Post hoc analysis showed similar trend. In the results, worry and relaxation were significantly different from each other, t (210) = 2.59, p = .010, but rumination and worry, t (194) = .91, p = .363, and rumination and relaxation, t (214) = .07, p = .945 were not significantly different (see Table 11). Figure 4 shows changes in RSA in sad exposure condition.

Comparison between the two time trends showed that worry, t (190) = 2.41, p = .017 and relaxation, t (230) = 2.30, p = .022 had significant differences in their directions. Unlike worry and relaxation, changes in rumination were uniform over the two time trends, t (198) = .036, p = .720 (see Table 12).

Fear exposure: Similar to amusement exposure, interaction between induction and time was marginally significant in fear exposure, F (2, 154) = 2.82, p = .063 (see Table 9). Among three different inductions, worry was the only induction which yielded significant change in RSA score from its baseline, β = -.47, t (113) = -2.07, p = .041, d = -.43). In this analysis, rumination, β = .05, t (117) = .26, p = .800, d = .05) and relaxation, β = .10, t (121) = .54, p = .593, d = .10)

did not show any significant changes, (see Table 10). Consistent with simple slope analysis in amusement exposure, post hoc comparison showed that worry was marginally distinct from relaxation, t (206) = 1.95, p = .053. However, worry and rumination, t (202) = 1.21, p = .229, and rumination and relaxation, t (226) = 1.64, p = .102 were not distinct from each other (see Table 11).

On the induction to exposure time trend, significant interaction between induction and time was found, F (2, 154) = 4.17, p = .017 (see Table 9). On this time trend, worry induction did not show significant change over time, β = .35, t (113) = 1.58, p = .118, d = .03. Results showed that only rumination induction decreased RSA score in response to fear exposure, (β = -.31, t (117) = -1.84, p = .068, d = -.35). Relaxation did not make any significant change on this time trend, β = -.25, t (121) = -1.49, p = .140, d = -.28 (see Table 10). Post hoc analysis showed that rumination was significantly different from worry, t (202) = 2.38, p = .018 (see Table 11). In addition, in the post hoc analysis, worry and relaxation were distinct from each other, t (206) = 2.16, p = .032. However, rumination and relaxation, t (226) = .269, p = .788 were not significantly different from each other in terms of their RSA score changes over time (see Table 11).

Comparison between the slopes on the two time trends show that the two slopes of worry were marginally different in their directions. Worry decreased RSA from its baseline to induction and then the RSA score got increased during fear exposure, t (182) = 2.59, p = .010. Other than worry, rumination, t (222) = 1.47, p = .144, and relaxation, t (230) = 1.39, p = .165 inductions did not show significant differences between the two time trends (see Table 12). Figure 5 also shows changes in RSA in fear exposure condition.

Amusement Exposure: In the amusement exposure condition, interaction between time and induction was significant, $F(2, 308) = 3.61$, $p = .029$ (see Table 9.) Follow up simple slope analysis revealed that worry was the only induction which significantly decreased RSA from its baseline, $\beta = -.49$, $t(117) = -2.66$, $p = .009$, $d = -.55$. Rumination, $\beta = -.17$, $t(113) = -.78$, $p = .437$, $d = -.15$, and relaxation, $\beta = .15$, $t(121) = .83$, $p = .407$, $d = .15$, did not make any significant change on this time trend. (see Table 10). When comparing slopes by induction types, changes in worry was significantly different from that in relaxation, $t(206) = 2.51$, $p = .013$. However, in the post hoc comparison, worry was not differentiated from rumination, $t(202) = 1.16$, $p = .248$, and also rumination was not different from relaxation, $t(226) = 1.13$, $p = .259$. (see Table 11).

On the induction to exposure time trend, none of significant interactions were found in the mixed model (see Table 9). However, simple slope analysis revealed that worry showed significant change in RSA score, $\beta = .44$, $t(117) = 2.80$, $p = .006$, $d = .58$. In the slope analysis, rumination, $\beta = .52$, $t(113) = 1.09$, $p = .278$, $d = .21$ and relaxation, $\beta = -.22$, $t(121) = -1.42$, $p = .158$, $d = -.26$ were not significant (see Table 10). Post hoc analysis by induction type showed that worry and relaxation were significantly different from each other, $t(206) = 2.99$, $p = .003$. However, in the post hoc test, worry was not distinct from rumination, $t(202) = .17$, $p = .863$ and rumination was not different from relaxation, $t(226) = 1.48$, $p = .140$ (see Table 11).

Post hoc comparison between the two time trends showed that the two worry slopes were significantly different from each other, $t(182) = 3.85$, $p < .001$. In response to worry, RSA score became significantly decreased from baseline and it became significantly increased during amusement exposure. However, rumination, $t(222) = 1.31$, $p = .191$, and relaxation, $t(230) =$

1.57, p = .117 did not yield any significant differences over the two time trends (see Table 12).

Figure 6 shows changes in RSA in amusement exposure condition.

Contrast Avoidance Scores

Sad Coping

In sad coping, only induction showed marginally significant main effect, F (2, 183) = 2.74, p = .067 (see Table 13). Results from Bonferroni post hoc analysis indicated that participants reported rumination as more effective than worry in coping with sadness (p = .090). However, rumination and relaxation (p = 1.000), and worry and relaxation (p = .134) were not different from each other in their coping scores. Figure 7 shows sadness coping score by induction type and group.

Fear Coping

In coping with fear, interaction between induction and group yielded marginally significant effect, F (2, 182) =2.31, p = .06 (see Table 13). Results from post hoc analysis showed that the GAD group reported significantly better coping with fear after engaging in the worry induction than the control group (p = .025). In the worry induction, GAD group and MDD group did not present different coping score (p = .630). In addition, MDD group and control group were not distinct from each other (p = .593). Furthermore, participants with GAD marginally coped better with the fear clip when they had worried compared to prior relaxation (p = .092). Differences between the worry induction and rumination induction were not significant in GAD group (p = .777). Figure 8 shows fear coping score by induction type and group.

Amusement Coping

Analysis of variance (ANOVA) showed that there were significant main effects of induction on the amusement coping score, F (2, 184) = 10.57, $p < .001$. In addition, a main effect of group was also marginally significant, F (2, 184) = 2.41, $p = .092$. However, interaction between induction and group was not significant, F (4, 184) =.169, $p = .954$ (see Table 13). Regarding the main effects of induction, participants in the relaxation induction reported better coping with the amusement video clip than those in rumination and worry ($p < .001$). However, rumination and worry were not distinct from each other in their amusement coping scores ($p = 1.000$). Post hoc analysis on the group differences showed marginally significant effects indicating that the MDD group coped better with amusement than the GAD group regardless of induction type ($p = .091$). However, there was no significant difference between the control and MDD group ($p = 1.000$) and the control and GAD groups ($p = .431$). Figure 9 shows sadness coping score by induction type and group.

Chapter 4. Discussion

Although previous literature implicates that rumination and worry may share similar mechanisms, they have never been systematically compared within individuals with MDD and GAD with respect to emotional and psychophysiological processing. Recognizing this issue, we proposed that the similarities between the two inductions are based on their pursuit of emotional constancy. Through the prism of the Contrast Avoidance Model of Worry (Newman & Llera, 2011; Newman et al., 2014), we tested whether rumination could be characterized by an aversion to a sharp shift toward negative emotions. Similar to findings in the previous study on worry (Llera & Newman, 2014), we predicted that rumination would boost negative emotionality in

comparison to the baseline (Hypothesis 1). Also, we estimated that rumination would attenuate further sharp increases in negative emotions in response to negative exposure (Hypothesis 2). In addition, we also predicted that unlike worry, rumination would lead to little or no decrease in heart rate variability (Hypothesis 3). Furthermore, as individuals with GAD in the previous study (Llera & Newman, 2014) perceived worry as more helpful in coping with sharp emotional shift, we predicted that individuals with MDD would present greater preference for rumination (Hypothesis 4).

Due to the inconsistencies in the induction methods, we first examined the validity of two different types of induction tasks and adopted a non-phrase reading self-administered induction task. The greater efficacy of the non-phrase reading self-administered induction task was likely due to the personalized nature of the stimuli. Previous evidence has shown that personalized stimuli can yield a more dysphoric response (Rottenberg, Gross, & Gotlib, 2005). In addition, for more accurate measures of the effects of rumination and worry, we took into account three different stages of effect, including baseline, induction and exposure. Along with subjective emotional responses, we assessed heart rate variability using RSA scores.

Consistent with our fist hypothesis, both rumination and worry increased dysphoric moods compared to baseline measures. In contrast, relaxation did not increase any of the negative emotions. This increased dysphoric tendency is consistent with, and has been evidenced by an ample number of studies which utilized rumination and/or worry inductions. In a series of experimental studies, researchers have found that both worry and rumination increased negative emotionality from the baseline. (Llera & Newman, 2014; McLaughlin, Borkovec, et al., 2007; McLaughlin, Mennin, & Farach, 2007; Verkuil, Brosschot, Borkovec, & Thayer, 2009; Zetsche, Ehring, & Ehlers, 2009).

The results of this experiment also supported our second hypothesis. Consistent with our predictions, rumination and worry led to an avoidance of a sharp negative contrast during negative exposure tasks. Contrary to this, relaxation gave rise to a sudden upsurge of negative emotions. These results indicate that the maintenance of rumination could be well conceptualized by the contrast avoidance theory. Whereas, previous theories of worry have demonstrated that worry facilitates avoidance of negative emotional experience (e.g., intolerance of uncertainty model of GAD and emotion dysregulation model of GAD). Results of this study showed that the negative perseveration actually increases negative emotionality, and the sustained negative emotions function as an avoidance of a sudden contrast to greater negative emotions. The new findings of the current study were contributed by the theoretical and methodological improvements made in the contrast avoidance theory of worry (Llera & Newman, 2014; Llera & Newman, 2010b; Newman & Llera, 2011; Newman et al., 2014). As it has been reviewed by Newman and Llera (2011), previous avoidance models have several limitations. First of all, they did not distinguish somatic response to worry from somatic response to stressor following worry. In addition, the models did not differentiate emotional avoidance from avoidance of emotional processing. Furthermore, methodologically, none of the pre-existing models discriminated the use of a resting baseline from the use of an induction baseline.

When testing our third hypothesis, we found further results supporting our predictions. In our study, rumination yielded inconsistent fluctuations in heart rate variability across different exposure conditions and in most cases, it did not yield any significant changes. The only significant change in rumination was a decrease in RSA scores in the induction to fear exposure time trend. However, given that rumination did not make any significant changes prior to the fear exposure, and that this decrease of fear from rumination induction were not consistent across

different trials, this decrease could be due to the effects of the fear stimuli. Unlike rumination, worry consistently decreased heart rate variability from the baseline and impeded further decrease of heart rate variability during negative exposures, which were in line with results from the subjective reports. These results implicate that the two types of inductions have different cardiac reactivity, which are nuanced by the type of the stressors. The strong association between worry and heart rate variability might be due to the contextual character of worry. As it has been theorized by Borkovec et al. (1983), worry is characterized by an anticipatory anxiety about future events. However, unlike worry, the focus of rumination is perseveration of past negative events, which are often presented as a form of self-reflection rather than threat perception (Nolen-Hoeksema et al., 2008). Therefore, threat perception in worry could be more salient than in rumination, leading to increased cardiac defensive reactivity, which was presented as lower heart rate variability in this study. The non-significant effect of rumination on the heart rate variability has been verified by the two laboratory studies (Aldao et al., 2013; Key et al., 2008). Although the two previous studies have found significant relationship between rumination and reduced heart rate variability, their results could be due to the different rumination induction method used in their studies. In one of the previous studies, participants were asked to recall episodes in which they felt intense anger or rage (i.e., being insulted, experiencing abusive or unfair treatment, witnessing others receiving unfair or abusive treatment) (Ottaviani et al., 2009). Considering that anger and rage are as closely related to the fight or flight response as anxiety is, the participants may have experienced more active cardiac defensive reactivity similar to worry induction, compared to the typical self-reflective and depressive rumination. In addition, since the study did not control effects of worry, the cardiac reactivity could have been contaminated by the effects of worry.

Results from the contrast avoidance questionnaire partially supported our fourth hypothesis. In the current study, the main effect of rumination predicted better coping with sad contrast. However, the effect was not exclusive to the MDD group, but found across all groups. Different from rumination, worry predicted better coping with fear, particularly in the GAD group. In addition, unlike our anticipation, MDD participants did not perceive relaxation as less helpful in coping with negative emotional exposure, but only GAD group presented more aversion to relaxation prior to fear exposure. These results implicate that participants with GAD may have greater sensitivity to the contrast effects, and thereby hold stronger positive beliefs on worry than participants with MDD do for rumination.

When testing these hypotheses, we were able to find specificity of rumination and worry in their emotional responses. Rumination showed greater reactivity to sadness, and worry was more closely related to fear. Although both induction tasks successfully increased negative emotionality after baseline, simple slope analysis showed that sadness was substantially more increased by rumination, and fear was markedly escalated by worry. In addition, as explained above, the contrast avoidance effect of rumination was prominent in response to sad exposure, whereas the contrast avoidance effect of worry was more salient in the fear exposure condition. Similar tendencies are found in the previous contrast avoidance study. Although the previous experimental study examined multiple different domains of emotions in each exposure condition, when only considering emotions corresponding to the video exposure targets (i.e., sadness in sad exposure and fear in fear exposure), we were able to find that worry effectively attenuated a sharp increase of fear in response to fear video exposure. However, worry did not decrease sadness elicited from sad video exposure as much as it did for fear (Llera & Newman, 2014).

Even though none of the previous studies examined effects of rumination induction regarding its contrast avoidance effect, several evidences have shown that rumination has heightened responsiveness to sadness. In one of the previous studies, rumination was associated more with sadness than fear (Zetsche et al., 2009). In the other study, effects of rumination were significantly greater during sad exposure than in other types of exposures (Aldao et al., 2013). In addition, in a study which assessed effects of rumination in response to a laboratory stressor in children, rumination showed greater reactivity to sad stressors than to fear stressors (Borelli, Hilt, West, Weekes, & Gonzalez, 2014). These findings implicate that although rumination and worry are based on similar emotion processing mechanisms, their emotional reactivity can vary depending on the context of stressors.

Based on these findings, we suggest the following clinical implications. The results of this study evidenced that the contrast avoidance effect functions as the maintenance factor of negative perseveration. A reason for why individuals continuously engage in rumination and worry could be that it brings about a greater sense of controllability over aversive emotional contrast. In return, this emotional benefit could function as a powerful reinforcer, which could motivate individuals to further administer those negative perseverations. However, maintenance of the contrast avoidance tendency cannot be a constructive coping mechanism, but it could serve as a risk factor of abundant problems. Although individuals may favor the negative emotional contrast, rumination and worry accompany negative emotions, and an ample number of studies have shown that the repetitive negative affect can increase the risk of psychological problems such as depression, anxiety and other axis I disorders (Ehring & Watkins, 2008; Kuyken, Watkins, Holden, & Cook, 2006; Wilkinson, Croudace, & Goodyer, 2013). In addition, previous studies found that negative perseveration increases risk for alcohol-related issues

(Ciesla, Dickson, Anderson, & Neal, 2011) and coronary heart diseases (Kubzansky et al., 1997). In addition, negative perseveration does not necessarily have its basis on reality. In a series of studies which measured reality of worrisome anticipation, 84%-91% of the anticipated catastrophes never happened, and among the events that actually happened, most individuals coped well with those situations (Borkovec, Hazlett-Stevens, & Diaz, 1999; LaFreniere & Newman, in press). In addition, although individuals reported rumination was more grounded on reality in a previous study, ruminative thoughts were more correlated to negative events which already happened in the past (Watkins et al., 2005). In addition, previous evidence showed that the dysphoric mood induced by rumination develops pessimism towards interpersonal conflicts and hinders effective problem solving (Lyubomirsky & Nolen-Hoeksema, 1995). Considering the irreversibility of events, and risk of having associated problems, neither worry nor rumination could be constructive emotional coping strategies.

Therefore, for clients with pathological rumination and worry, intervention should focus on cognitive restructuring of their maladaptive positive beliefs about worry or rumination. For this, psychoeducation could be provided to enhance their understanding of the functions of rumination and worry regarding their contrast avoidance of negative affect. In addition, by facilitating clients' insights on negative outcomes of repeated contrast avoidance, patients are more expected to successfully reconstruct their positive beliefs about rumination and worry. Along with this, we believe that habituation techniques also can be helpful to allow patients to attenuate their sensitivity towards emotional contrast. By administering graduated exposure to emotional contrast stimuli, we expect patients to become more resilient to a sharp shift in negative emotions and thus feel less need to sustain negative perseveration.

However, a question remains regarding how effectively patients could understand the mechanisms of contrast avoidance. Results from the contrast avoidance questionnaire showed that participants in either rumination or worry induction were indeed aware of the utility of the contrast avoidance tendency at their overt cognitive level. This overt perception would be helpful for patients' and therapists' efforts in identifying the vicious cycle of contrast avoidance effect. Therefore, we expect that psychoeducation and cognitive restructuring approaches could be effective in reforming maladaptive cognitive patterns underlying the contrast avoidance effects.

However, several limitations of the current study should be noted. Since the theory is relatively newer than other theories, it has never been tested with respect to the treatment efficacy. In addition, there are also limitations due to the nature of the participants in the current study. Although we applied a diagnostic cut off to screen participants, they were recruited from a college population. For better generalizability, we encourage future studies to include treatment seeking individuals. In addition, gender differences were not examined due to the limited number of male participants. However, considering previous evidence that suggests depressive rumination is more prevalent among females, there may be significant gender differences in the processing of rumination and worry and their contrast avoidance effects. Furthermore, although this study focused on the test of contrast avoidance effect in MDD and GAD populations, considering that negative perseveration is prevalent across different types of anxiety disorders (e.g. obsessive compulsive disorder, post-traumatic stress disorder, and panic disorder) (Leyro, Berenz, Brandt, Smits, & Zvolensky, 2012; Michael, Halligan, Clark, & Ehlers, 2007; Wahl et al., 2011), more empirical evidence should be accumulated with respect to these different types of anxiety disorders in order to verify the specificity of the Contrast Avoidance theory to GAD. Moreover, one of the other limitations of this study was that it took place in an experimentally

controlled laboratory. Therefore, our results require further replication in more naturalistic

settings and may lead to better generalizability by being conducted using ecological momentary

assessment.

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APPENDIX A: TABLES

Table 1
Descriptive Statistics (N = 191)

	MDD group (N =54) M (SD)	GAD group (N = 51) M (SD)	Control group (N = 86) M (SD)	F	p
Age	18.71 (2.34)	18.80 (1.50)	18.40 (.70)	1.16	.315
Gender (Female:Male)	43:11	43:8	68:18	.30	.740
BDI-II	**25.39 (6.22)**	**8.47 (2.90)**	**3.91 (3.54)**	**420.61******	**<.001**
GAD-Q-IV (Continuous)	**6.07 (3.06)**	**9.41 (1.37)**	**1.20 (.87)**	**327.15******	**<.001**

$^{\dagger}p < .1, {}^{*}p < .05, {}^{**}p < .01, {}^{***}p < .001$

Note. GAD-Q-IV, Dimensional Score of Generalized Anxiety Disorder Questionnaire for DSM-IV (In this study, categorical questionnaire was used as for the screening measure); BDI-II, Beck Depression Inventory-II

Table 2
Baseline Emotion Scores by Participant Group (N = 191)

	MDD group (N =54) M (SD)	GAD group (N = 51) M (SD)	Control group (N = 86) M (SD)	F	P
Sadness	**1.15 (1.60)**	**.45 (.90)**	**.19 (.64)**	**13.90******	**<.001**
Fear	**.35 (1.03)**	**.47 (.95)**	**.13 (.70)**	**2.72**†	**.069**
Amusement	**.56 (1.11)**	**1.31 (1.87)**	**.95 (1.54)**	**3.21***	**.042**

$^{\dagger}p < .1, {}^{*}p < .05, {}^{**}p < .01, {}^{***}p < .001$

Table 3

Manipulation Check Scores by Induction Condition

Manipulation Scale	Induction Type M (SE)						Participant Group M (SE)					
	Rumination (N = 59)	Worry (N = 71)	Relaxation (N = 61)	F	P	η_p^2	MDD (N = 54)	GAD (N = 51)	Control (N = 86)	F	p	η_p^2
Ruminative	6.50 (.15)	4.14 (.13)	1.39 (.14)	137.32***	<.001	.14	4.28 (.14)	4.24 (.15)	3.50 (.12)	18.53***	<.001	.02
Worried	3.88 (.14)	5.58 (.12)	1.47 (.13)	110.11***	<.001	.11	3.95 (.13)	3.73 (.14)	3.24 (.11)	22.73***	<.001	.03
Relaxed	3.04 (.15)	2.82 (.14)	7.28 (.14)	104.90***	<.001	.11	4.29 (.15)	4.13 (.16)	4.71 (.12)	18.72***	<.001	.02

$^\dagger p < .1, {}^* p < .05, {}^{**} p < .01, {}^{***} p < .001$

Note. Manipulation check scores are reported in non-transformed values.

Table 4

Manipulation Check Scores by Exposure Type

Manipulation Scale	Exposure Type M (SE)						Participant Group M (SE)					
	Sad Video (N = 191)	Fear Video (N = 191)	Amusement Video (N = 191)	F	P	η_p^2	MDD (N = 54)	GAD (N = 51)	Control (N = 86)	F	p	η_p^2
Sad	6.01 (.15)	1.59 (.09)	1.19 (.06)	628.10***	<.001	.69	3.07 (.21)	3.01 (.21)	2.79 (.16)	.65	.524	.00
Fearful	2.47 (.14)	4.66 (.16)	1.17 (.05)	203.36***	<.001	.42	2.98 (.19)	2.82 (.18)	2.60 (.13)	1.43	.241	.00
Amused	1.56 (.09)	2.40 (.13)	6.31 (.16)	391.79***	<.001	.58	3.40 (.23)	3.65 (.22)	3.31 (.16)	.80	.452	.00

$^\dagger p < .1, {}^* p < .05, {}^{**} p < .01, {}^{***} p < .001$

Note. Manipulation check scores are reported in non-transformed values.

Table 5

Linear Mixed Model for Baseline to Induction, Induction to Exposure Time Trends, Induction, Group and Their Interactions Predicting Subjective Emotions

Emotion	Fixed Effect	Baseline to Induction		Induction to Exposure	
		F	*p*	*F*	*P*
Sad	Intercept	212.14***	<.001	892.71***	<.001
	Time	116.76***	<.001	248.67***	<.001
	Induction	33.52***	<.001	25.202***	<.001
	Group	12.96***	<.001	4.036*	.019
	Time × Induction	42.15***	<.001	22.13***	<.001
	Time × Group	.91	.405	3.12*	.046
	Induction × Group	1.333	.259	1.06	.377
	Time × Induction × Group	1.471	.213	1.16	.332
Fearful	Intercept	150.38***	<.001	558.48***	<.001
	Time	79.61	<.001	99.52***	<.001
	Induction	37.37***	<.001	25.25***	<.001
	Group	8.58***	<.001	3.67*	.027
	Time × Induction	34.32***	<.001	13.76***	<.001
	Time × Group	1.97	.143	1.62	.201
	Induction × Group	1.57	.185	1.02	.398
	Time × Induction × Group	1.66	.161	1.66	.162
Amused	Intercept	75.34***	<.001	953.54***	<.001
	Time	28.43***	<.001	943.81***	<.001
	Induction	.17	.843	2.13	.122
	Group	4.90**	.008	1.80	.169
	Time × Induction	12.32***	<.001	.206	.814
	Time × Group	1.41	.246	1.68	.189
	Induction × Group	.49	.747	.87	.481
	Time × Induction × Group	1.24	.295	3.68**	.007

†$p < .1$, *$p < .05$, **$p < .01$, ***$p < .001$

Table 6

Means of Dependent Variables at Baseline, Induction and Exposure, and Simple Slopes of Fixed Effects for Baseline to Induction and Induction to Exposure Time Trends Predicting Subjective Emotions

Dependent Variable	Induction Type	Baseline *M* (SE)	Induction *M* (SE)	Exposure *M* (SE)	Baseline to Induction				Induction to exposure			
					Slope	*t*	*p*	*d*	Slope	*t*	*p*	*d*
Sadness	Rumination	.74 (.25)	3.95 (.25)	5.17 (.25)	**.60**	**-8.17*****	**<.001**	**1.51**	**.29**	**-3.25****	**.001**	**.60**
	Worry	.44 (.22)	2.20 (.22)	5.29 (.22)	**.45**	**-5.93*****	**<.001**	**1.00**	**.61**	**-9.04*****	**<.001**	**1.52**
	Relaxation	.51 (.23)	.33 (.23)	4.58 (.23)	-.08	.88	.378	-.16	**.82**	**-15.95*****	**<.001**	**2.90**
Fear	Rumination	.54 (.24)	1.68 (.24)	3.88 (.24)	**.33**	**-3.76*****	**<.001**	**.70**	**.46**	**-5.54*****	**<.001**	**1.02**
	Worry	.56 (.21)	3.21 (.21)	3.87 (.21)	**.56**	**-8.00*****	**<.001**	**1.35**	**.20**	**-2.46*****	**.015**	**.42**
	Relaxation	.18 (.23)	.11 (.22)	3.20 (.22)	-.06	.68	.496	-.12	**.73**	**-11.60*****	**<.001**	**2.11**
Amusement	Rumination	1.17 (.22)	.21 (.22)	5.29 (.22)	**-.36**	**4.13*****	**<.001**	**-.76**	**.85**	**-17.27*****	**<.001**	**3.19**
	Worry	1.16 (.20)	.13 (.20)	5.27 (.20)	**-.36**	**4.51*****	**<.001**	**-.76**	**.83**	**-17.79*****	**<.001**	**3.00**
	Relaxation	.49 (.21)	.67 (.21)	5.57 (.21)	.10	-1.06	.291	.19	**.82**	**-15.54*****	**<.001**	**2.83**

$^{†}p < .1$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 7

Simple Slope Comparison by Induction Type (Subjective Emotions)

Dependent Variable	Slope	Rumination vs. Worry			Rumination vs. Relaxation			Worry vs. Relaxation		
		t	*df*	*p*	*t*	*df*	*p*	*t*	*df*	*p*
Sadness	Baseline to Induction	**3.10****	**256**	**.002**	**7.74*****	**236**	**<.001**	**5.44*****	**260**	**<.001**
	Induction to exposure	**3.15****	**256**	**.001**	**5.59*****	**236**	**<.001**	**2.47*****	**260**	**.014**
Fear	Baseline to Induction	**3.05****	**256**	**.002**	**3.80*****	**236**	**<.001**	**7.86*****	**260**	**<.001**
	Induction to exposure	**2.47*****	**256**	**.014**	1.62	236	.107	**4.74*****	**260**	**<.001**
Amusement	Baseline to Induction	.40	256	.692	**3.77*****	**236**	**<.001**	**4.10*****	**260**	**<.001**
	Induction to exposure	.14	256	.889	.66	236	.509	.54	260	.591

$^{†}p < .1$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Table 8

Simple Slope Comparison between Baseline to Induction and Induction to Exposure (Subjective Emotions)

Dependent Variable	Induction Type	Baseline to Induction vs. Induction to Exposure		
		t	df	P
Sadness	Rumination	2.94**	232	.003
	Worry	-3.40***	280	<.001
	Relaxation	-13.66***	240	<.001
Fear	Rumination	2.16*	232	.031
	Worry	3.29**	280	.001
	Relaxation	-11.13***	240	<.001
Amusement	Rumination	-16.29***	232	<.001
	Worry	-16.62***	280	<.001
	Relaxation	-12.45***	240	<.001

$^\dagger p < .1, ^* p < .05, ^{**} p < .01, ^{***} p < .001$

Table 9

Linear Mixed Model for Baseline to Induction, Induction to Exposure Time Trends, Induction, Group and Their Interactions Predicting RSA Scores

Exposure Type	Fixed Effect	Baseline to Induction		Induction to Exposure	
		F	p	F	p
Sadness	Intercept	.45	.502	2.76†	.098
	Time	.62	.431	.03	.867
	Induction	1.28	.281	2.54†	.081
	Group	.26	.770	.06	.943
	Time × Induction	1.49	.229	.65	.525
	Time × Group	.27	.763	.16	.849
	Induction × Group	.11	.978	.45	.771
	Time × Induction × Group	.59	.671	.49	.745
Fear	Intercept	1.04	.309	6.44*	.012
	Time	1.80	.182	.09	.760
	Induction	2.28	.106	1.92	.150
	Group	1.38	.255	.23	.797
	Time × Induction	2.82†	.063	4.17*	.017
	Time × Group	2.46†	.089	2.55†	.082
	Induction × Group	.39	.815	.23	.924
	Time × Induction × Group	.71	.588	.31	.872
Amusement	Intercept	1.10	.295	.48	.491
	Time	2.30	.131	.68	.410
	Induction	2.34	.100	1.51	.223
	Group	1.04	.355	.20	.817
	Time × Induction	3.61*	.029	.96	.386
	Time × Group	1.57	.212	.46	.633
	Induction × Group	1.16	.329	.47	.759
	Time × Induction × Group	.50	.734	1.04	.386

$^\dagger p < .1, ^* p < .05, ^{**} p < .01, ^{***} p < .001$

Table 10

Mean RSA Scores at Baseline, Induction and Exposure, and Simple Slopes of Fixed Effects for Baseline to Induction and Induction to Exposure Time Trends Predicting RSA Scores

HRV (Exposure Condition)	Induction Type	Baseline M (SE)	Induction M (SE)	Exposure M (SE)	Baseline to Induction				Induction to exposure			
					Slope	t	p	d	Slope	t	p	d
Sadness	Worry	0 (.14)	-.64 (.10)	-.34 (.13)	**-.64**	**-3.62*****	**<.001**	**-.74**	**.29**	**1.73†**	**.087**	**.35**
	Rumination	0 (.14)	.05 (.51)	-.17 (.13)	.05	.09	.925	.02	-.22	-.42	.679	-.08
	Relaxation	0 (.03)	.22 (.10)	-.04 (.09)	.22	1.35	.181	.03	**-.26**	**-2.00***	**.048**	**-.37**
Fear	Worry	0 (.15)	-.47 (.18)	-.12 (.14)	**-.47**	**-2.07***	**.041**	**-.43**	.35	1.58	.118	.03
	Rumination	0 (.13)	.04 (.11)	-.27 (.12)	.05	.26	.800	.05	**-.31**	**-1.84†**	**.068**	**-.35**
	Relaxation	0 (.13)	.10 (.13)	-.15 (.10)	.10	.54	.593	.10	-.25	-1.49	.140	-.28
Amusement	Worry	0 (.15)	-.49 (.11)	-.06 (.11)	**-.49**	**-2.66******	**.009**	**-.55**	**.44**	**2.80******	**.006**	**.58**
	Rumination	0 (.13)	-.17 (.16)	.36 (.44)	-.17	-.78	.437	-.15	.52	1.09	.278	.21
	Relaxation	0 (.13)	.15 (.11)	-.08 (.11)	.15	.83	.407	.15	-.22	-1.42	.158	-.26

†*p* < .1, *p* < .05, **p* < .01, ***p* < .001

Table 11

Simple Slope Comparison by Induction Type (RSA scores)

Exposure Condition (HRV)	Slope	Rumination vs. Worry			Rumination vs. Relaxation			Worry vs. Relaxation		
		t	df	p	t	df	p	t	df	p
Sadness	Baseline to Induction	1.21	194	.229	.30	214	.764	**3.57*****	**210**	**<.001**
	Induction to exposure	.91	194	.363	.07	214	.945	**2.59***	**210**	**.010**
Fear	Baseline to Induction	1.21	202	.229	1.64	226	.102	**1.95†**	**206**	**.053**
	Induction to exposure	**2.38**	**202**	**.018**	.269	226	.788	**2.16†**	**206**	**.032**
Amusement	Baseline to Induction	1.16	202	.248	1.13	226	.259	**2.51***	**206**	**.013**
	Induction to exposure	.17	202	.863	1.48	226	.140	**2.99******	**206**	**.003**

†*p* < .1, *p* < .05, **p* < .01, ***p* < .001

Table 12
Simple Slope Comparison between Baseline to Induction and Induction to Exposure (RSA scores)

Exposure Condition (HRV)	Induction Type	Baseline to Induction vs. Induction to Exposure		
		t	*df*	*P*
Sadness	Rumination	.036	198	.720
	Worry	**2.41***	**190**	**.017**
	Relaxation	**2.30***	**230**	**.022**
Fear	Rumination	1.47	222	.144
	Worry	**2.59***	**182**	**.010**
	Relaxation	1.39	230	.165
Amusement	Rumination	1.31	222	.191
	Worry	**3.85***	**182**	**<.001**
	Relaxation	1.57	230	.117

†*p* < .1, *p* < .05, **p* < .01, ***p* < .001

Table 13
Analysis of Variance for Induction, Group and Their Interactions Predicting Contrast Avoidance Scores

Emotion Coping	Fixed Effect	*F*	*P*
Sadness	Intercept	**283.20***	**<.001**
	Induction	**2.74†**	**.067**
	Group	1.02	.362
	Induction × Group	1.92	.109
Fear	Intercept	**292.08***	**<.001**
	Induction	.04	.96
	Group	.27	.766
	Induction × Group	**2.31†**	**.06**
Amusement	Intercept	**236.78***	**<.001**
	Induction	**10.57***	**<.001**
	Group	**2.41†**	**.092**
	Induction × Group	.169	.954

†*p* < .1, *p* < .05, **p* < .01, ***p* < .001

APPENDIX B: FIGURES

Figure 1. Sadness from Baseline to Induction to Exposure (Subjective Emotions)

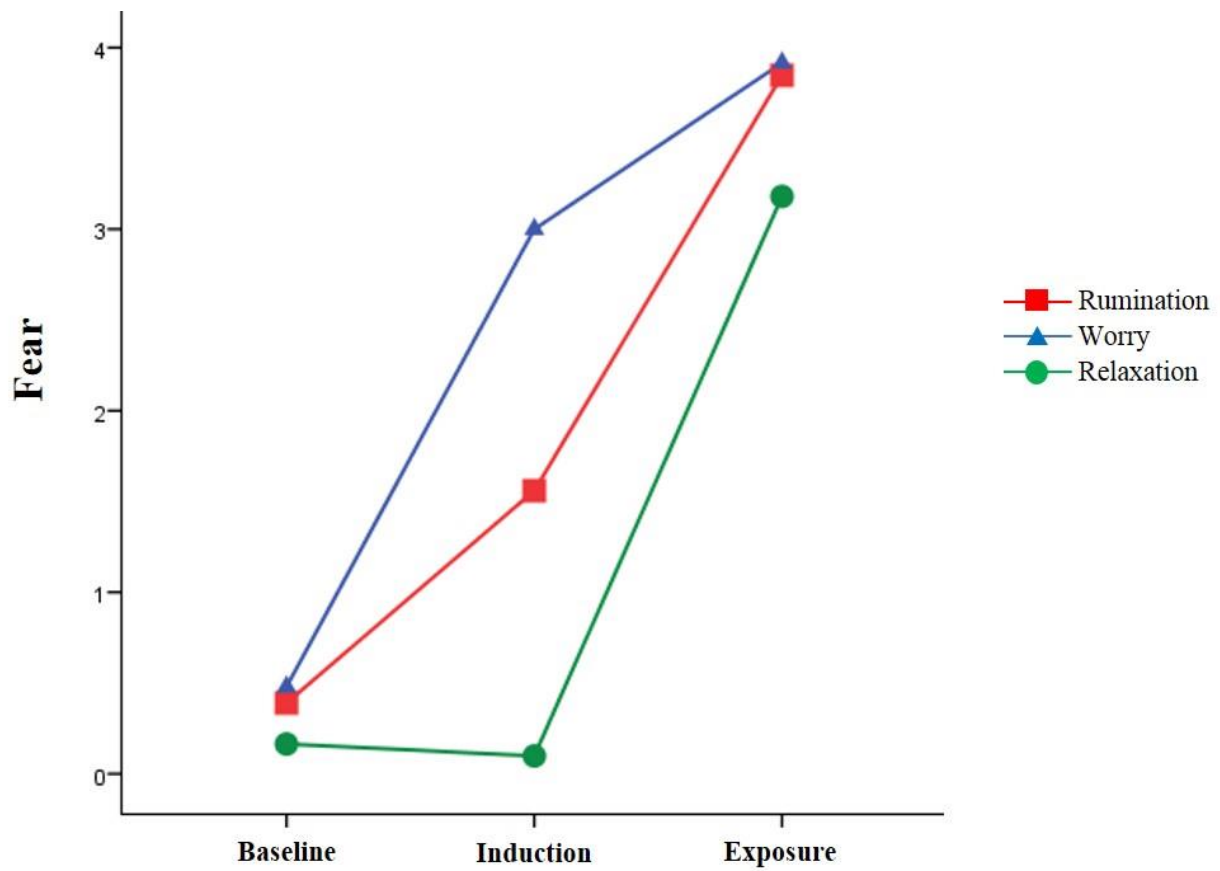*Note.* Scores are reported in non-transformed values.

Figure 2. Fear from Baseline to Induction to Exposure (Subjective Emotions)

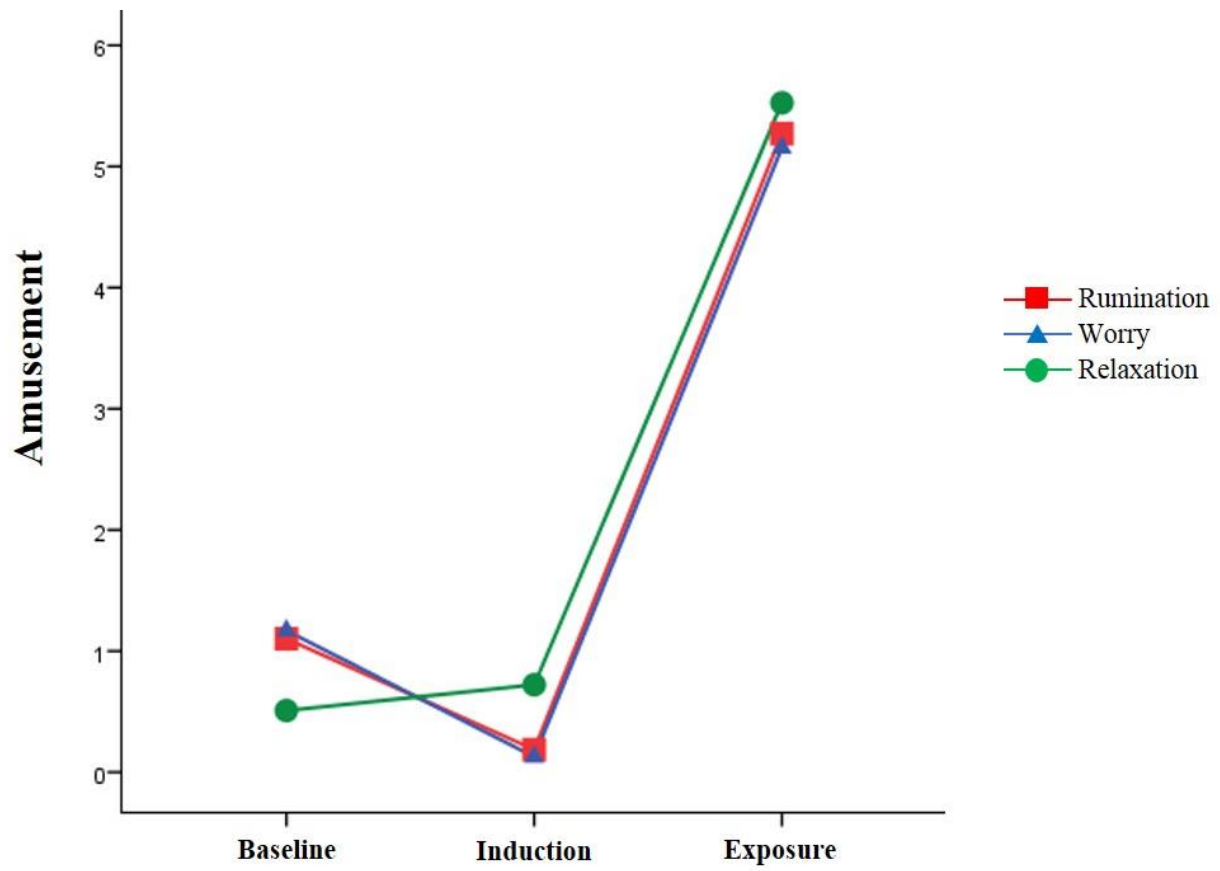*Note.* Scores are reported in non-transformed values.

Figure 3. Amusement from Baseline to Induction to Exposure (Subjective Emotions)
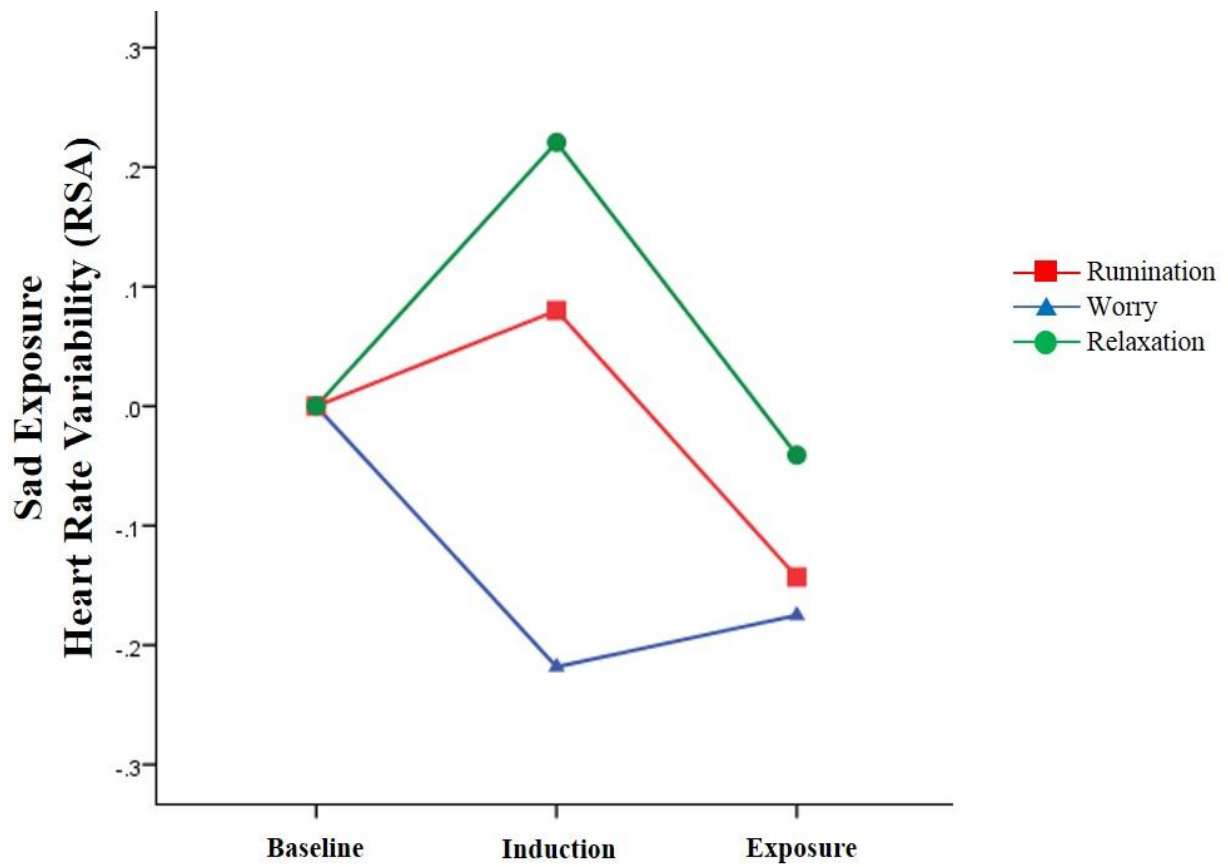
Note. Scores are reported in non-transformed values.

Figure 4. Heart Rate Variability in Sad Exposure Condition (RSA Score)
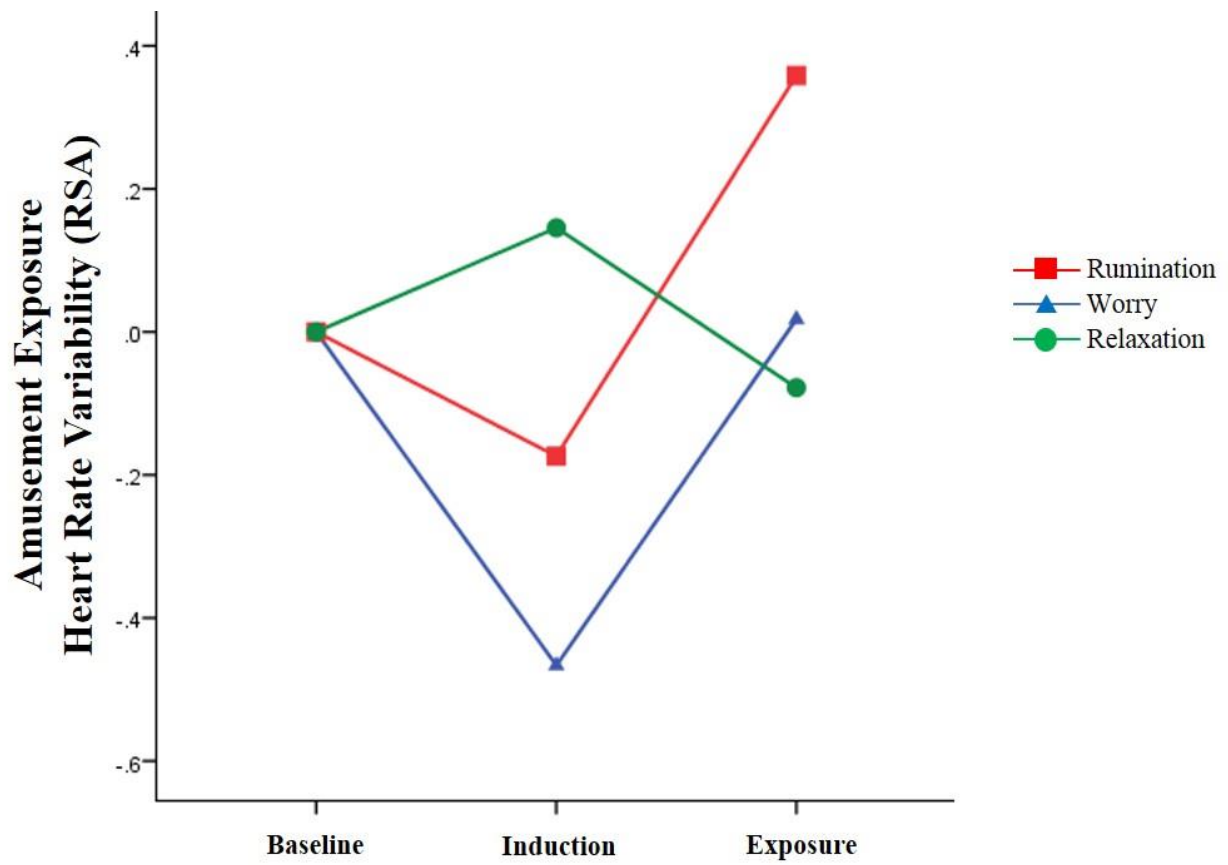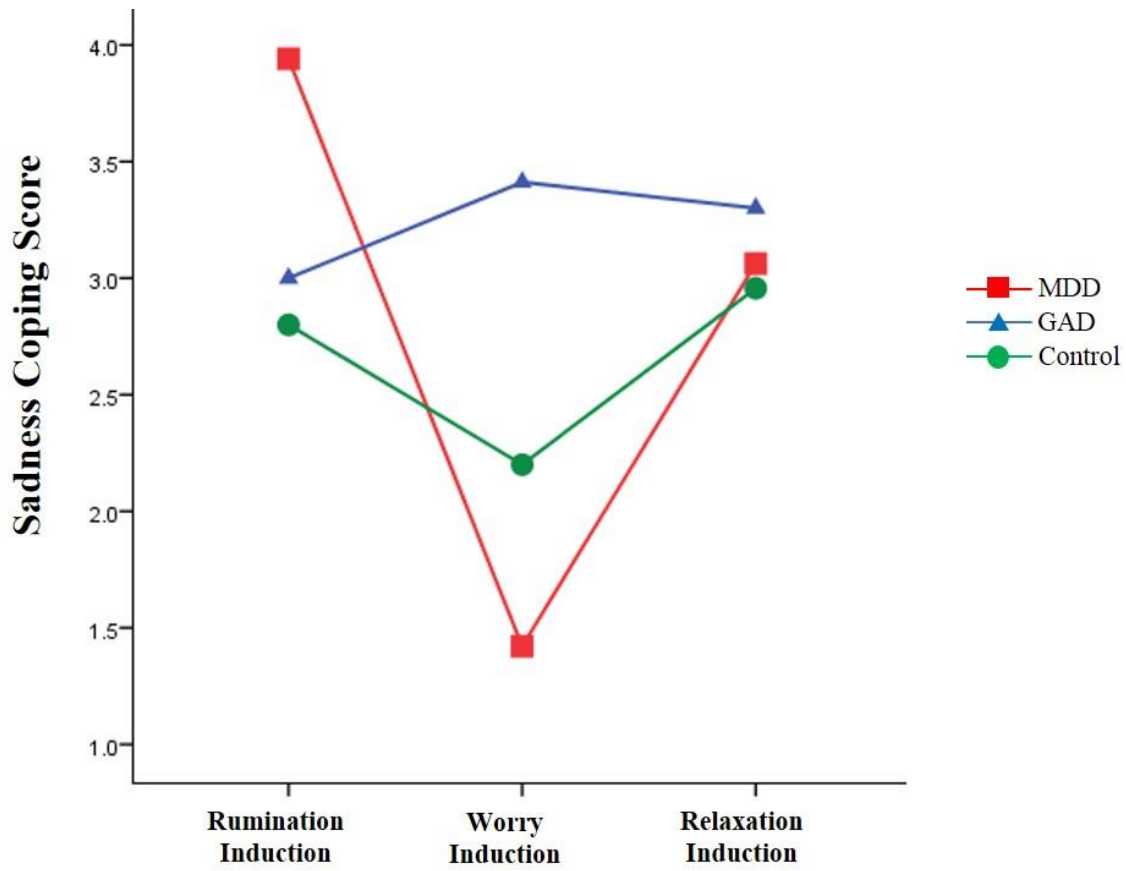
Note. Scores are reported in log-transformed values.

Figure 5. Heart Rate Variability in Fear Exposure Condition (RSA Score)

Note. Scores are reported in log-transformed values.

Figure 6. Heart Rate Variability in Amusement Exposure Condition (RSA Score)

Note. Scores are reported in log-transformed values.

Figure 7. Sadness Coping Score by Induction Type and Group (Contrast Avoidance Questionnaire)
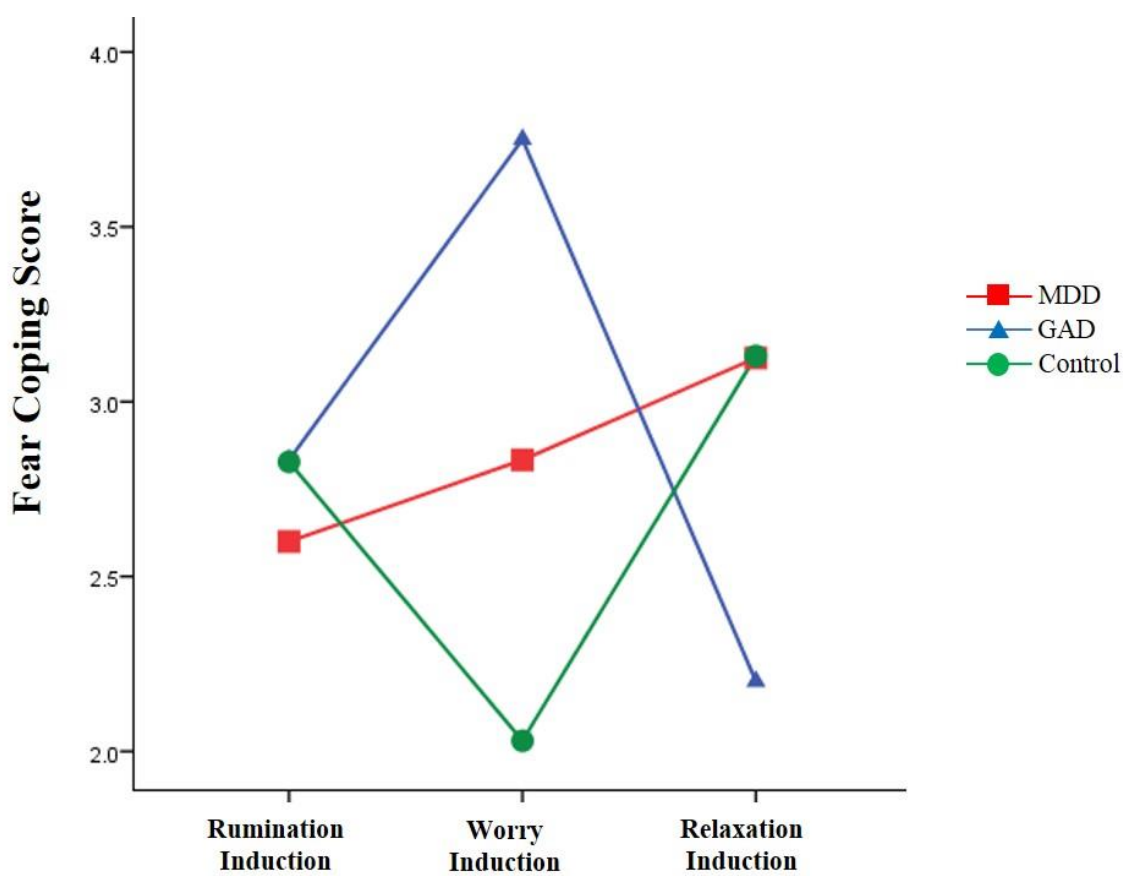
Note. Scores are reported in non-transformed values.

Figure 8. Fear Coping Score by Induction Type and Group (Contrast Avoidance Questionnaire)

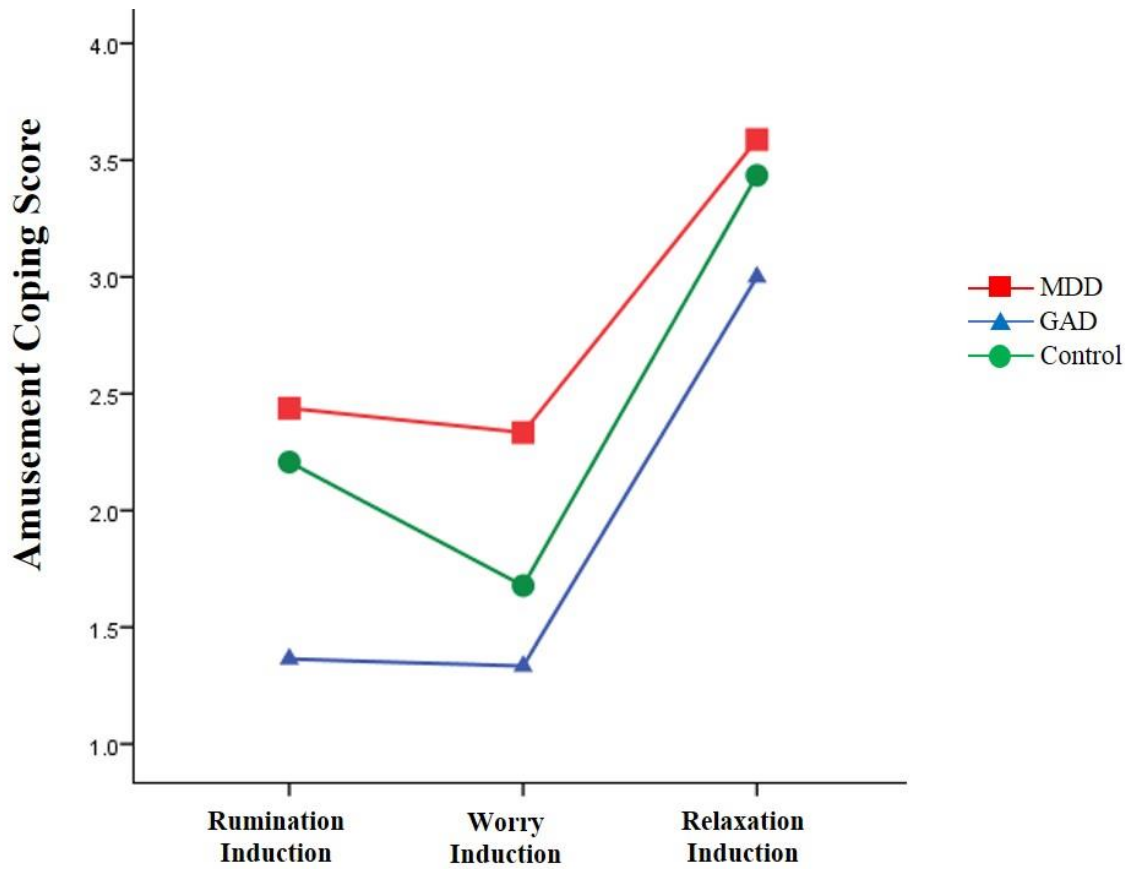*Note.* Scores are reported in non-transformed values.

Figure 9. Amusement Coping Score by Induction Type and Group (Contrast Avoidance Questionnaire)

Note. Scores are reported in non-transformed values.