THE EFFECTS OF POSITIVE EMOTION ON COGNITIVE REAPPRAISAL

BY

YU SONG

A Thesis Submitted to the Graduate Faculty of

WAKE FOREST UNIVERSITY GRADUATE SCHOOL OF ARTS AND SCIENCES

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF ARTS

Psychology

May 2018

Winston-Salem, North Carolina

Approved By:

Christian E. Waugh, PhD, Advisor

Wayne E. Pratt, PhD, Chair

D. Eranda Jayawickreme, PhD

Jeffrey L. Weiner, PhD

ACKNOWLEDGMENTS

Completing the thesis is a milestone for my master program. Throughout the thesis project, I got tremendous help from many wonderful people. I would first like to thank my advisor Dr. Christian Waugh. Dr. Waugh has a good sense of humor, but he becomes very serious when it comes to the research. We met weekly and spent lots of hours on our experiments. He was always able to put forward insightful ideas when I was stuck with my experiment results and lead me in the right direction when I did not know what to investigate next. He was the one who helped me get out of my comfort zone and kept pushing my limits. My writing skills and data analytics skills have dramatically improved during the past two years. I cannot express my gratitude enough to him.

I am deeply grateful to research assistants who helped me conduct the experiment: John Thurber, Gabrielle Milando, Foster Stroup, Joseph Kastrenakes, Aylin Aguilar Aguilar, Aaron Sunil, and Jessica Rivers. Without their hard work and dedication, I would not be able to graduate on time.

I would also like to acknowledge Dr. Wayne Pratt, Dr. Eranda Jayawickreme, and Dr. Jeffrey Weiner as readers of my thesis, and I am gratefully indebted to them for their patience, kindness, and valuable comments on this thesis.

Finally, I must express my deepest gratitude to my parents and friends. Their unconditional love, care, and trust provide me with the most powerful motivation in the pursuit of my dreams. They are always there when I am on the verge of an emotional breakdown. They are like a beacon of light guiding me through the darkness. I love them so much, always and forever.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS AND TABLES

ABSTRACT

Both experiencing incidental positive emotion and using reappraisal strategies can help people regulate their emotions when coping with stress. Studies exploring individual differences have found strong associations between positive emotion and cognitive reappraisal success. However, the causal direction between positive emotion and reappraisal remains unclear. We hypothesized that incidental positive emotion might facilitate cognitive reappraisal through multiple mechanisms, such as cognitive facilitation, adaptive meaning-making, and motivational mechanisms. To test the possible facilitating effects of positive emotion on reappraisal, we applied virtual reality (VR) to elicit positive or neutral emotional contexts, used a speech task to induce stress, and instructed participants to reappraise the stressor positively. Participants reported their emotions and thoughts throughout the experiment. Although being in an incidental positive context helped to increase individuals' positive emotions, results of the present study failed to support the facilitation effects of incidental positive emotion on cognitive reappraisal, and possible explanations are provided in the discussion. However, we found that being in an incidental positive context facilitated the relations between the increase of positive thoughts and increase of positive emotions, and future investigation should explore the possible role of individual differences in the facilitation effect of incidental positive emotion on relations between emotions and thoughts.

Keywords: positive emotion, cognitive reappraisal, facilitation effect, VR

INTRODUCTION

As an inevitable part of our daily life, stress is typically defined as either a stimulus (stressor) that triggers people's negative emotion and physiological arousal or a response that involves multiple systems to prepare individuals for the stressful events or situations (Folkman, 2013). According to a nationwide poll carried out in January 2017 across the United States (APA, 2017), the percentage of people who suffered physical and stressful symptoms, such as feeling anxious and overwhelmed, over the past month has significantly increased since 2007, and has risen to almost 80%. Additionally, although technology and social media have dramatically improved life for many Americans, nearly 40% of adults claim that discussions about culture and politics on social media bring about more stress to their life (APA, 2017).

Stress has its positive and negative sides. Moderate levels of stress have been found necessary for personal growth and boost performance in various activities (Kirby et al., 2013; Quick, Cooper, Nelson, Quick, & Gavin, 2003). Research suggests that manageable levels of perceived stress can counteract the negative effects of oxidative damage (Aschbacher et al., 2013), and people who experience moderate levels of stress are better able to manage adversity and maintain good mental health compared with those who have too little or too much stress (Seery, Leo, Holman, & Silver, 2010). While moderate levels of stress can bring about a wide range of benefits that are essential for performance and survival, acute stress poses high health risks for individuals. Decades of research has found that acute stress not only has profound detrimental effects on physical health outcomes but may also add risks to the immune system and make individuals more vulnerable to diseases in the long run (Chida & Steptoe, 2010; Folkman & Moskowitz, 2000; McNally et al., 2015). Stress was found to be associated with the slow healing of wounds (Maple et al., 2015), cortisol response in asthma (Trueba, Simon, Auchus, & Ritz, 2016), and the fatigue caused by rheumatoid arthritis (Evers et al., 2014). Poor stress regulation may exacerbate the disease symptoms of mental illness including anxiety disorders (Campos et al., 2013), post-traumatic stress disorder (PTSD; McNally et al., 2015), and substance abuse (Andersen & Teicher, 2009).

Incidental Positive Emotion and Stress Regulation

To mitigate the negative impacts of stress, people apply a range of methods to promote stress regulation, and one of the most robust protective factors to down-regulate stress is experiencing incidental positive emotions. Different from integral emotions which arise from the situation itself (e.g., an individual feels anxious about the risky choice), incidental emotions are not necessarily related to or originate from the emotion-eliciting situation but can be carried over from one situation to another, which may influence people's behaviors and emotions (Lerner, Li, Valdesolo, & Kassam, 2015; Quigley & Tedeschi, 1996).

Considerable research shows that incidental positive emotions are highly useful in the midst of stress and can reduce the harmful effects of psychological stress, thus protecting people from many stress-related diseases (Folkman, 2008; Kent, Davis, & Reich, 2013; Okely, Weiss, & Gale, 2017). Researchers have conducted a population-based longitudinal study to investigate the relationship between positive affect and the risk of coronary heart disease (CHD), and the result shows increased positive emotions are protective against ten-year incident CHD (Davidson, Mostofsky, & Whang, 2010). Fredrickson et al. (2000) posit that incidental positive emotions reduce the negative impact of stress by undoing the cardiovascular aftereffects brought by negative emotions. They conducted a physiological study, which explores the undoing effect of incidental positive mood in the context of negative emotional arousal. In their study, participants first underwent a stressful event by preparing for a judged speech, and then they were exposed to different stimuli inducing positive or neutral mood states unrelated to the stressful event. Results indicate that incidental positive emotions expedite cardiovascular recovery caused by negative stimuli.

Cognitive Reappraisal and Stress Regulation

Incidental positive emotions can attenuate negative emotions and physiological responses evoked by stress directly. In fact, such effects can be achieved by cognitive strategies as well (Gross & Thompson, 2007), such as cognitive reappraisal, suppression, and distraction. While some of the regulatory tactics (e.g., suppression) are usually regarded as more maladaptive to reduce distress, reappraisal has long been viewed as an adaptive tactic to attenuate negative emotions (Gross, 1998).

Cognitive reappraisal involves reframing or altering the interpretation of a stressful situation or a stimulus in a different way that changes the emotional impacts of stress responses (Gross, 2001; John & Gross, 2004; Larsen & Prizmic, 2004). Experimental evidence suggests that the successful implementation of reappraisal can mitigate emotional responses at multiple levels, such as experience, expression, and autonomic physiology (Giuliani, McRae, & Gross, 2008; McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008). Specifically, by using cognitive reappraisal in the laboratory setting, participants experienced a decrease in psychological and physiological indexes of emotional reactions after they watched an emotional film clip or saw unpleasant stimuli

(Gross, 1998; Jackson, Malmstadt, Larson, & Davidson, 2000). Accumulating evidence suggests the same pattern of results indicating cognitive reappraisal is associated with more adaptive cardiovascular responses, less negative emotion, better interpersonal functioning, and more subjective and psychological well-being (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Balzarotti, Biassoni, Villani, Prunas, & Velotti, 2016; Gross & John, 2003; Mauss, Cook, Cheng, & Gross, 2007). Cognitive reappraisal provides an efficient approach to the mitigation of negative emotions in the context of acute stress and distress (Engen & Singer, 2015; Garnefski & Kraaij, 2006; Moskowitz, Hult, Bussolari, & Acree, 2009; Troy, Wilhelm, Shallcross, & Mauss, 2010), and serves as a protective factor for positive health outcomes.

Under the umbrella of cognitive reappraisal, people may implement different types of reappraisal to achieve emotional goals (i.e., increasing positive emotions or decreasing negative emotions in stressful situations), and these different tactics also influence the outcome of cognitive reappraisal (McRae, Ciesielski, & Gross, 2012). For example, positive reappraisal involves reinterpreting situational aspects of a target stimulus from positive perspectives and finding benefits in the given circumstance. In contrast to positive reappraisal, detached reappraisal focuses on thinking about stimuli in an unemotional, objectively, and detached way. It requires the disengagement from emotional responses to the target situation (Shiota & Levenson, 2009). An fMRI study has distinguished the neural mechanisms between the two sub-types of strategies. Positive reappraisal may depend on brain areas related to selective attention, language, and verbal working memory, including dorsal PFC and left-lateralized systems, while detached reappraisal relies more on areas involved in attentional control and selfrelevance evaluation, such as right PFC and medial systems (Ochsner & Gross, 2008). Shiota and Levenson (2012) compared the effects of these two strategies by looking at emotional experience, thought content, physiological reactivity, and facial expressions of emotion. Results show that both types of cognitive reappraisal can reduce overall emotional responses to negative stimuli, yet produce different profiles of physiological responses. While detached reappraisal seems to reduce cardiac reactivity to stressors, positive reappraisal tends to increase it, implying possible differences in mechanisms of the two sub-types of reappraisal. Based on the different mechanisms and effect of the two types of reappraisal, it is critical to instruct participants to reappraise in a specific way. In the present study, we were more interested in how positive reappraisal attenuates the negative emotion evoked by stressors, so we followed the rules described in previous studies to instruct participants to reinterpret the stressor in a positive way. In addition, cognitive reappraisal in this paper refers to the positive reappraisal.

Incidental Positive Emotions May Promote Cognitive Reappraisal

Studies exploring individual difference have found strong associations between positive emotion and cognitive reappraisal success (McRae, Jacobs, Ray, John, & Gross, 2012). However, the causal direction between positive emotion and cognitive reappraisal remains undetermined, and the mechanism underlying this process is largely unexplored. Cognitive reappraisal requires multiple cognitive control abilities (Schmeichel & Tang, 2015). For instance, cognitive reappraisal requires the ability to inhibit distractors and other interfering appraisals (Kalisch, Müller, & Tüscher, 2015). Since positive emotions have been found to facilitate a range of cognitive processes (Chermahini & Hommel, 2012; Chun, Golomb, & Turk-Browne, 2011; Fredrickson, 2004; Fröber & Dreisbach, 2014; Vanlessen, Rossi, Raedt, & Pourtois, 2013) and the successful implementation of reappraisal relies on cognitive control, we proposed that positive emotions may facilitate reappraisal through altering cognitive processes.

Cognitive facilitation mechanisms. Although the present study does not aim to investigate the mechanisms underlying the proposed facilitation effects of positive emotion on cognitive reappraisal, we argue that such effect may stem from different mechanisms that positive emotion has an impact on, and these mechanisms support our investigation of the relation between positive emotion and cognitive reappraisal. First, positive emotions might facilitate reappraisal by broadening cognition (Fredrickson, 2004). According to the broaden-and-build theory, positive and negative emotions are independent of each other but still have complementary adaptive functions and physiological effect. To prepare individuals against potential dangers and threats, negative emotions tend to narrow and focus people's thoughts and actions in case of fight or flight. On the contrary, positive emotions broaden the cognitive repertoire which is previously narrowed by negative affect and stimulate a creative and integrative thinking style (Chermahini & Hommel, 2012), and the increased flexibility is associated with individuals' ability to use reappraisal (Malooly, Genet, & Siemer, 2013). Specifically, affective flexibility is the ability that guarantees people to attend to and disengage from emotional stimuli flexibly. When reconsidering the meaning of a stressful event, people have to change their perspectives by focusing on emotionally neutral aspects while switching from emotionally negative aspects. In such case, people who have experienced positive emotions are likely to benefit from their enhanced cognitive flexibility and openness, which facilitate the generation of a new interpretation regarding the given stressful situation.

In addition to the route of broadening cognition, the broaden-and-build theory also proposes that positive emotions help to build and restore personal resources, especially cognitive resources that refer to the amount of information used for analysis and control people have access to (Franconeri, Alvarez, & Cavanagh, 2013), resulting in enhanced comprehension and task performance (Fredrickson, 1998). Cognitive resources promoted by positive emotions can be drawn on later in different emotional states or at other times, contributing to reconsidering the meaning of an event even in a stressful situation. As a strategy of emotion regulation, cognitive reappraisal costs cognitive resources (Sheppes & Meiran, 2008). With the help of positive emotions, more cognitive resources are available to process information, evaluate stimuli, and control behavioral responses (Isen, 2008; Tice, Baumeister, Shmueli, & Muraven, 2007). Meanwhile, accumulating resources give rise to an increase in cognitive capacity, and evidence in both laboratory and more naturalistic settings has indicated that the increase in cognitive capacity is associated with an enhanced emotion regulation ability (Schmeichel & Demaree, 2010). Therefore, the ability of cognitive reappraisal may be augmented by positive emotions through the production of cognitive resources. These two possible mechanisms mentioned above overall can be characterized as the cognitive facilitation mechanism, which focuses on the cognitive functions of positive emotion.

Adaptive meaning-making mechanisms. In addition to the cognitive facilitation mechanisms, another route through which positive emotions influence cognitive reappraisal is the adaptive meaning-making mechanism. Emotions themselves may serve as information that signals a safe or dangerous environment. Emotions provide people not only with a quick and heuristic evaluation of an object but also the evaluative information (e.g., value, importance) of the target (Clore & Palmer, 2009). In general, negative emotions signal negative attributes of a situation, implying there is a problem in the environment that needs to be solved. By contrast, positive emotions signal positive attributes of a specific situation, implying everything in the environment is good (Clore & Palmer, 2009; Turowski et al., 2014). According to the affect-as-information theory (Clore & Palmer, 2009), experiencing a negative stimulus can induce a feeling of uncertainty or threat, while experiencing incidental positive emotions in the midst of a stressor may provide people with information that the environment is safe, and they are supposed to feel optimistic and confident (Gervais & Wilson, 2005). According to the adaptive meaning-making mechanism, positive emotions can assist people in changing the meaning of their thoughts by infusing prior negative appraisal with incidental positive information provided by positive affect, which helps to reduce their negative emotions under stress in the end.

Motivational mechanisms. Apart from the mechanisms of cognitive facilitation and adaptive meaning-making, positive emotions may also impact cognitive reappraisal through the motivational functions of positive mood. According to the hedonic contingency theory, people are motivated to maintain or even improve their pleasant feelings, and they will carefully evaluate the outcomes of a decision in order to prolong their positive mood (Hirt, Devers, & McCrea, 2008; Tugade & Fredrickson, 2007). Therefore, compared with those in a neutral or negative mood state, people in a positive mood state have extra motivation to take actions, such as cognitively reappraising a stressful event, to capitalize on the potential for feeling good induced by these incidental positive emotions. This may result in a facilitation effect of incidental positive emotion on reappraisal.

In summary, the effects of positive emotions on cognitive reappraisal can be achieved by cognitive facilitation (i.e., broadening cognition, and building cognitive resources), adaptive meaning-making (i.e., affect-as-information), and motivational approaches (i.e., maintaining a positive mood). Based on such predictions, we previously conducted two studies to explore the possible facilitation effects of positive emotion on cognitive reappraisal. In these two studies, we adapted a widely used and effective picture-based reappraisal paradigm. However, results showed that experiencing incidental positive emotions did not facilitate the use of reappraisal. Reflections on such results inspired us to improve the experiment design of the current research.

Factors Influencing the Effects of Positive Emotion on Reappraisal

In the two studies, we used pictures from the International Affective Picture System (IAPS) to elicit participants' incidental positive and neutral mood states. After viewing induction pictures, participants were instructed to view a negative or neutral target picture selected from IAPS with one of two instructions, either LOOK or CHANGE, that required participants to respond naturally (LOOK) or change their thoughts to increase positive feelings toward the target picture (CHANGE). Subsequently, participants reported their positive and negative feelings. Inconsistent with our hypotheses, these studies showed that the interaction of the incidental emotional context (positive vs. neutral) and instructions for negative target pictures (LOOK vs. CHANGE) was not significant. More importantly, compared with neutral mood states, positive emotion induction did not significantly influence the effects of reappraisal on positive or negative emotion ratings, failing to demonstrate the beneficial effects of positive emotion on cognitive reappraisal.

The previous studies conducted in our lab failed to indicate that incidental positive emotions facilitate cognitive reappraisal. However, scrutiny of our experiment design revealed several possible factors that potentially lead to non-significant interaction between emotional context (positive vs. neutral) and instructions (LOOK vs. CHANGE).

We applied a picture-based design in previous research, and emotions induced by pictures are relatively fleeting and weak, which may be difficult to carry over to the negative target pictures during ratings. Therefore, we adopted a more effective and powerful method of emotion induction in our present study. Virtual reality (VR) was employed to evoke intense affective feelings (Estupiñán, Rebelo, Noriega, Ferreira, & Duarte, 2014). Researchers investigating the effects of VR on mood induction have found that virtual environment (e.g., park and village) can elicit different affective states (e.g., joy, excitement, anxiety, and sadness) merely by modifying specific characteristics of these environments, such as lighting conditions and time of day. For example, a park full of beautiful flowers and trees in sunny daytime can induce a relaxed, contented mood. In contrast, a gloomy park with a few lanterns can make participants feel anxious and uneasy (Toet, van Welie, & Houtkamp, 2009). By enhancing the immersive experience in the 3D world, virtual reality appears to be more effective for emotion induction compared with other low immersive mood-induced strategies, such as watching a video or playing a video game displayed on conventional 2D computer screens (Hupont, Gracia, Sanagustin, & Gracia, 2015; Visch, Tan, & Molenaar, 2010). Notably, the ability of VR to elicit a particular emotion not only depends on the virtual scenario presented to users but also their subjective experience of the virtual scenario measured by the sense of presence (Felnhofer et al., 2015). Therefore, we asked participant in the post-task survey to rate their sense of presence as an indicator of successful manipulation of presence in the present study.

In addition to picture-based design, the primary task of our previous experiment took participants nearly 40 minutes to complete, giving rise to a total of 100 minutes for finishing the entire experiment. During the experiment, participants were likely to feel overwhelmed by a large number of images presented during the primary task and switching from positive and neutral mood states frequently. Individuals have to apply more attentional control to regulate emotion during frequent switching (Johnson, 2009), resulting in little attention paid to positive or neutral induction images that may facilitate the next reappraisal. Hence, we kept the emotion induction unchanged throughout the experiment to ensure that participants were able to immerse themselves in the incidental positive context that mechanisms of the facilitation effects of positive emotion on cognitive reappraisal were fully activated and subsequent use of incidental emotion evoked by VR was available.

Powerful emotion induction and participants' high involvement are key to investigating the role of positive emotion. However, it is also possible that the effects of incidental positive emotion on reappraisal are more salient under certain circumstances. Therefore, it is also necessary to create a favorable context when applying reappraisal strategies. Controllability, generally defined as the degree to which an individual can influence the outcomes of an event or a situation, can influence regulation tactics that individuals tend to apply when confronted with stressors (Heth & Somer, 2002). Controllability is an essential component that determines not only the adaptiveness of cognitive reappraisal but also efforts people put into stress regulation. Troy et al. (2013) suggest that cognitive reappraisal may be more adaptive when stressors are uncontrollable and when situations cannot be altered by implementing active coping strategies. This is because actively adapting to emotional situations under these contexts is the only beneficial thing people can do (Lazarus, 1993). In contrast, when taking actions can prevent negative outcomes, cognitive reappraisals can be highly maladaptive if they fail to make a move, which may lead to a worsened situation (Troy, Shallcross, & Mauss, 2013). Research shows that people in controllable situations tend to be more persistent when conquering negative setbacks (Bhanji, Kim, & Delgado, 2016). In addition, people in a controllable situation are more likely to use active strategies to solve the existing problems, whereas individuals in an uncontrollable situation tend to apply emotion-based strategies, such as reappraisal (Bonanno & Burton, 2013). By creating an uncontrollable stressful situation, we could promote the use of cognitive reappraisal while controlling for efforts put into problem-solving which might confound with efforts elicited by incidental positive emotions.

The Present Study

The goal of the present study was to investigate the possible effects of positive emotion on cognitive reappraisal through improved experiment paradigm and design. VR was utilized to elicit participants' positive or neutral mood state, and speech task was used to elicit participants' stressful feelings. Following the phase of emotion induction, participants underwent an uncontrollable stressful event (anticipating an upcoming speech task) with or without the instruction of cognitive reappraisal (i.e., positive reappraisal) while viewing specific virtual scenarios. Then they delivered the speech in front of a judge and experienced a recovery period during which the emotion induction implemented by VR continued. Positive and negative emotions were rated throughout the experiment, and participants' thoughts toward virtual scenario and the speech task were also recorded during anticipation and instructed anticipation period. Based on the effects of positive emotion on stress regulation, we predicted that compared with being in a neutral context, being in a positive context would help to mitigate participants' negative feelings while increasing positive feelings when facing a stressor. Since reappraisal that serves as a goal-oriented strategy is typically effective even in neutral contexts (Webb, Miles, & Sheeran, 2012), we hypothesized that individuals in both positive and neutral emotional contexts would down-regulate their negative emotions and up-regulate their positive emotions by responding to the stressful event with cognitive reappraisal. More importantly, we hypothesized that being in an incidental positive context might facilitate the use of cognitive reappraisal compared with being in a neutral context. This would be reflected by higher positive/lower negative emotional ratings at the instructed anticipation (stress-evoking) phase during which people were told to reappraise the stressor for those in an incidental positive context compared with those in a neutral context.

In addition to the emotion outcomes, we also examined the thoughts people generated while regulating their emotions. When experiencing a stressful event, we hypothesized that participants would generate more positive and fewer negative thoughts toward the stressor if they were in an incidental positive context than those were in a neutral context. Regarding the effects of reappraisal, compared with merely anticipating the stressor without reappraisal instruction, participants would generate more positive and fewer negative thoughts toward the stressor (i.e., speech task) when the instruction of reappraisal was given. Moreover, being in an incidental positive context may facilitate the generation of positive thoughts about the stressful event during the instructed anticipation (reappraisal) period than being in a neutral context.

METHOD

Pre-Registration

This study was pre-registered on March 15, 2018, on the Open Science Framework (OSF; project citation: osf.io/kwrmx/). By April 6, we have recruited 128 participants and achieved our goal of sample size preregistered on OSF. Study materials and procedures were strictly implemented as the descriptions in preregistration. In Results, we noted which analyses were preregistered as confirmatory or exploratory as well as those that were exploratory after we collected the data.

Participants

Participants were 128 (71 female) undergraduate students recruited through the Wake Forest Introductory Psychology subject pool, aged 18-21 (M = 18.93, SD = .844). All participants met our inclusion criterion that participants were not visually impaired and had no prior experience of sickness when using virtual reality devices. They were granted 0.5 credit towards their psychology course for their participation in our study.

Sample size rationale. There was no research indicating the effect size of interaction between emotion induction (positive, neutral) and instruction (reappraisal, control) during stress anticipation. Instead, we calculated a predicted effect size in our study based on a hypothesized ratio of the effect size of the interaction to an established main effect size of the instructions. To do so, we first carefully selected studies from a meta-analysis paper (Webb, Miles, & Sheeran, 2012) which had within-subjects designs and compared instructions of reappraising emotional stimulus with no instruction or instructions of looking naturally. The average main effect (f) of reappraisal instruction vs. no instruction/look naturally instruction from previous relevant studies was 0.30. We estimated that the effect size of interaction was around half of the main effect size of the instructions, so the effect sizes (f) for the interaction of emotion induction and instruction during stress should be .15. We then conducted a power analysis using G*Power, determining that we need 120 participants to obtain 90% power at alpha = .05[1]. To account for the possibility that some of the participants might be excluded in data analysis, we increased the sample size to 128.

Materials

Virtual reality. Virtual scenarios were more effective to induce consistent and lasting mood states (Felnhofer et al., 2015). In this study, we used virtual scenarios constructed by our lab to induce positive or neutral emotions. In a pilot study, participants viewed different virtual scenarios (e.g., office, waterfall, Aurora, beach) which were used to induce positive or neutral mood states. After viewing each scenario, participants rated how pleasant and unpleasant they felt when exploring these scenarios. In the end, the beach and office VR scenarios were selected because they outperformed other videos in reliably inducing positive and neutral mood states, respectively. Therefore, we applied these two scenarios in the present study, and the manipulation check confirmed that VR worked effectively in emotion induction.

Virtual scenarios were programmed with WebVR and displayed with a mounted VR headset (Oculus Rift) which has an externally applied head tracking system so that participants can have a first-person view of these scenarios. We also played the sound of these scenarios using built-in headphones of the VR headset to enhance participants'

[1] Considering that we adopted a two-tailed .025 alpha for each omnibus test in confirmatory analyses, we recalculated the effective power for 99 participants who were not excluded and ultimately got the actual power of the present study, which was .76.

immersive experiences. Throughout the experiment, participants were asked to explore the virtual setting while remaining seated on the chair when the headset was on.

Self-reported emotion. Positive and negative emotions were measured throughout the experiment using a 10-point scale (1 = not at all, 10 = very much). To facilitate participants' responses, however, what participants viewed on the VR display was a shaded bar which was white on the left side (indicating "not at all") and black on the right side (indicating "very much"). Participants' responses fell within different ranges of the bar were transformed into numbers (1-10) by the program. When rating scales popped up on the VR display, participants used an Oculus controller to report their current emotions (e.g., "How positive/negative do you feel right now"). The controller generated a blue laser line in VR headset that enabled participants to point the laser at a certain spot, and participants could press a trigger to confirm their responses.

Thought Content Questionnaire. The Thought Content Questionnaire (TCQ) in the present study was a 14-item self-report inventory, which was revised from a prior similar experiment in our lab (Yang et al., 2018). This questionnaire was designed to capture participants' thought processes when they were anticipating a stressful event (i.e., speech task). The 14 items were intentionally grouped into five categories: negative thoughts about the virtual scenario, positive thoughts about the virtual scenario, negative thoughts about the speech task (not including virtual scenarios), positive thoughts about the speech task, and other thoughts irrelevant to the speech task or the virtual scenario. With the controller, participants rated on a 10-point scale (1 = not at All; 10 = very much) when questions asking how much time they engaged in these thoughts popped up on VR display. To analyze different thoughts, we calculated and used the means of ratings for each category as an indicator of participants' thought processes. If participants missed more than one item per subscale, their means of this subscale were labeled as missing.

Post-task questionnaire. Post-task survey was comprised of basic demographic questions and manipulation checks. Given that the sense of presence may affect individuals' immersive and emotional experience (Felnhofer et al., 2015), participants were asked to rate their experienced presence of virtual environment with a single question (i.e., "Did you have a sense of 'being there' when exploring the virtual reality world in the study?"), which was commonly used in previous studies related to presense (Price, Mehta, Tone, & Anderson, 2011; Riva et al., 2007; Schuemie, Van Der Straaten, Krijn, & Van Der Mast, 2001). In manipulation checks, participants answered questions regarding the speech task and about the purposes of the experiment, and this was to test whether they were able to correctly follow the instructions given halfway through the anticipation of the speech task. Participants were also asked to assess how difficult it is to follow the reappraisal instructions and what percentage of time they were able to follow the instruction in anticipation of the speech task.

Procedure

Pre-task procedure. Upon arrival, participants were required to provide their written consent form in compliance with the Institutional Review Board guidelines at Wake Forest University. After participants provided their informed consent, the experimenter helped participants to put on the VR headset and adjusted the VR device to have the optimal display resolution. Subsequently, participants viewed a neutral virtual scenario that was distinct from scenarios presented at the emotion induction phase to experience VR. Then participants were trained to use a controller to rate their emotions and thoughts on a 10-point scale shown on the VR display.

At the end of the training, participants were pseudorandomly assigned to one of two groups (Emotion Induction: positive, neutral). The pseudorandom number list for assigning participants was created before conducting the experiment. This was to guarantee that both groups had an equal sample size of 30 participants. In order to avoid possible training biases from the experimenter, the experimenter did not know which condition the participant was assigned to until the end of the training. To do so, we made a pack of cards in advance, which had participants' experiment ID on one side and Emotion Induction assignment on the other side. The experimenter flipped the card to check condition after participants finished the training session.

Baseline. Following training, participants were asked to relax for 2 minutes, during which they saw a cross on a white blank screen through the VR headset. At the end of baseline period, 10-point scales were presented on the blank VR display, asking participants to report how positive and negative they felt at that moment (see Figure 1).

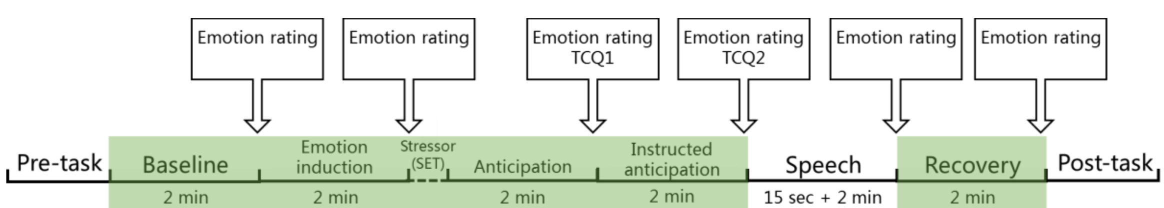

Figure 1. Timeline of the present experiment (phases in VR setting were highlighted in green)

Emotion induction. After the baseline phase, participants were assigned to either positive or neutral induction conditions and viewed different VR scenarios depending on their assigned condition. For those in the positive group, a positive emotional context was induced by displaying the positive scenario (i.e., beach) on participants' VR headset, whereas a neutral context was induced by the neutral office scenario for those in the neutral group. Participants were asked to freely explore the scenarios presented to them while remaining seated on the chair until they were told to complete the next task. Then the experimenter left the room. At the end of the 2-minute induction period, questions regarding positive and negative emotions popped up the VR display, and participants had maximum 10 seconds to answer each question. Following ratings was an instruction for participants to say 'done,' and it was at this time that the experimenter reentered the room.

Anticipation phase. When coming back to the room, the experimenter told participants that they were going to perform a speech task in a few minutes. Research has shown that merely anticipating a stressor (speech task) is efficient in inducing stress (Waugh, Panage, Mendes, & Gotlib, 2010). In the present study, participants were told that they were going to deliver an impromptu speech later in front of a judge. The judge would assess the clarity, coherence, and persuasiveness of their argument. However, the speech topic specific to each participant had not been decided yet. Before the judge arrived in a few minutes, participants were asked to wait quietly and keep exploring the virtual scenario freely. Then the experimenter left the room, leaving participants viewing the virtual scenario and reporting their emotions at the end of the 2-minute anticipation period. Subsequently, participants completed the first Thought Content Questionnaire (see Appendix) item by item displayed on the VR headset.

Instructed anticipation phase. After finishing the first TCQ, an instruction appeared on the VR display, telling participants to reappraise the upcoming speech task in a positive way while exploring the virtual scenario and waiting for the judge ("While keeping exploring the VR environment, please reinterpret or re-consider the upcoming speech task so that you feel as positive as you can. The judge will come shortly"). The reappraisal instruction was followed by another 2-minute experience of the same positive or neutral virtual scenario they had seen before. Participants rated their emotions at the end of the 2-minute instructed anticipation period and completed the second thought content questionnaire.

Speech phase. After completing the second TCQ, experimenter entered the room, told participants to take off the VR headset, and then left. Then a judge entered the room and told participants that they would be given 15 seconds to prepare for a 2-min persuasive public speech about "why you are a good friend." Then participants gave the speech in front of the judge during which the judge timed speech using a stopwatch and wrote down comments (this was to make participants believe that the judge was assessing their performance). After delivering the speech, participant put on the VR headset again to rate how positive and negative they felt at that time.

Recovery. After speech delivery phase, participants kept viewing the virtual scenario they had seen before. At the end of the 2-minute recovery period, participants reported their levels of positive and negative emotions.

Post-Task Procedure. At the end of the experiment, participants completed a post-task survey which consisted of demographic questions and manipulation checks on Qualtrics. Finally, participants were debriefed and granted credits for their participation.

Data Analysis

Inference criteria. As reflected by materials and procedures, we collected data on positive and negative ratings at different phases of the experiment and scores from two Thought Content Questionnaires. Because all the analyses in our study were performed twice, once for positive and once for negative ratings, we adopted a two-tailed .025 alpha for each omnibus test and a .05 alpha for follow-up contrast tests, but we still interpreted p-values between .025 and .05 in results.

Preregistered data exclusion. We strictly followed the rules of data exclusion that we preregistered. In manipulation checks, participants answered questions regarding instructions given in anticipation of the speech task and about the purposes of the experiment. We excluded the data from participants who demonstrated they failed to understand or failed to follow the instructions to reappraise the stressful event ($n = 20$). We also excluded those who were explicitly suspicious about the speech task (did not believe they that would have to give one) and who showed a complementary lack of increase in negative emotion/decrease in positive emotion during anticipation phase ($n = 10$). In addition, participants who showed no variability (all of their responses are the same) in emotional ratings across all phases ($n = 2$) were excluded as well, considering that these participants may not reflect on their emotions or that they did not follow instructions. In our preregistration, we also added another exclusion criterion that participants who refused to put on VR headset and/or gave an impromptu speech would be excluded, yet no participants were non-compliant. In total, we excluded 29 out of 128 participants (some participants qualified for multiple exclusion criteria) for a final $n = 99$ for further analyses. Excluding participants based on missing data were handled on an analysis by analysis basis, so that only participants who had all ratings for certain analysis were included in the analysis.

RESULTS

Preregistered Manipulation Check

To check the effectiveness of emotion induction in the current experiment, we first conducted two 2 (Emotion Induction: positive, neutral) x 2 (Phase: baseline, emotion induction) repeated-measures ANOVAs, with Emotion Induction as between-subjects variable, Phase as within-subjects variables, and the positive/negative ratings of emotions as dependent variables. Consistent with our expectations, for positive emotion, there was a significant interaction of Emotion Induction and Phase, $F(1, 88) = 15.00$, $p < .001$, $\eta^2_{\text{partial}} = .146$. The main effects of Phase, $F(1, 88) = 49.74$, $p < .001$, $\eta^2_{\text{partial}} = .361$, and Emotion Induction, $F(1, 88) = 15.16$, $p < .001$, $\eta^2_{\text{partial}} = .147$, were also significant. Follow-up comparisons of simple effects revealed that the significant interaction was due to a non-significant difference between the positive ($M = 5.08$, $SD = 2.66$) and neutral group ($M = 4.58$, $SD = 2.46$) at baseline, $F(1, 88) = 0.86$, $p = .357$, $\eta^2_{\text{partial}} = .010$, and a significant difference between two groups at emotion induction phase. Specifically, participants in an incidental positive context reported a higher level of positive emotion ($M = 8.00$, $SD = 1.62$) than those in a neutral context ($M = 5.43$, $SD = 2.16$), $F(1, 88) = 41.86$, $p < .001$, $\eta^2_{\text{partial}} = .322$, at emotion induction period, indicating that positive and neutral virtual scenarios were successful in inducing corresponding mood states. For negative emotion, there was a significant effect of Phase, $F(1, 92) = 13.81$, $p < .001$, $\eta^2_{\text{partial}} = .131$, such that participants reported a decrease in negative emotion from baseline ($M = 3.55$, $SD = 2.21$) to emotion induction phase ($M = 2.73$, $SD = 1.70$). The effect of Emotion Induction, $F(1, 92) = 5.68$, $p = .019$, $\eta^2_{\text{partial}} = .058$, was also significant, and participants in a neutral context (*M* = 3.55, *SD* = 1.65) reported more negative feelings than those in an incidental positive context (*M* = 2.73, *SD* = 1.65). However, the interaction of Phase and Emotion Induction, $F(1,92) = 2.39$, $p = .126$, $\eta^2_{\text{partial}} = .025$, was not significant.

Considering that presence is an indicator of the effectiveness of VR, we conducted a t-test on presence scores, which showed that there was not a significant difference between the positive and neutral group, $t(97) = .781$, $p = .437$, reflecting the comparable immersion experiences of VR as mood induction method for both conditions.

To test whether anticipation of the speech task in our study was sufficiently stressful, we compared emotion ratings from induction to anticipation phase by conducting two paired sample t-tests. There was a significant increase in negative emotion, $t(91) = 5.00$, $p < .001$, and a decrease in positive emotion, $t(64) = 4.79$, $p < .001$, from induction to anticipation phase in response to the stressful task. This confirmed that anticipating the speech task was effective in inducing stress.

Preregistered Confirmatory Analyses

We hypothesized that, relative to anticipation phase during which participants were not given any instructions to regulation stress, participants in the instructed anticipation phase when the instruction of reappraisal was conveyed would experience higher positive emotion and lower negative emotion, and the disparity of emotion between two phases could be further enlarged by positive emotions evoked in virtual scenarios. To test this primary hypothesis, we conducted two 2 (Emotion Induction: positive, neutral) x 2 (Phase: anticipation, instructed anticipation) mixed ANCOVA analyses, with self-reported positive and negative emotion as the dependent variables, respectively. For both ANCOVA analyses, Emotion Induction was between-subjects variable, and Phase was within-subjects variable, while emotion ratings of baseline served as a covariate to account for differences in emotion between participants upon arriving the lab.

For positive emotion, the main effect of Emotion Induction was significant, $F(1, 80) = 27.10$, $p < .001$, $\eta^2_{\text{partial}} = .253$, and participants in an incidental positive context ($M = 6.95$, $SD = 1.71$) overall reported more positive feelings than those in a neutral context ($M = 4.96$, $SD = 1.71$). However, the effect of Phase was not significant, $F(1, 80) = 1.03$, $p = .314$, $\eta^2_{\text{partial}} = .013$. There was a significant interaction of Phase and Emotion Induction, $F(1, 80) = 10.31$, $p = .002$, $\eta^2_{\text{partial}} = .114$, suggesting that changes from anticipation to instructed anticipation varied with Emotion Induction. To clarify the significant two-way interaction of Phase and Emotional Induction, we conducted a planned contrast to assess whether the change in ratings from anticipation to instructed anticipation phase was larger in the positive group than that of the neutral group. The planned contrast revealed that relative to individuals who were in a neutral context, individuals in an incidental positive context had a significantly smaller change in emotional ratings, $t(80) = -3.26$, $p = .002$. Comparisons of simple effects revealed that while participants in the neutral group experienced an increase in positive emotional rating from anticipation ($M = 4.33$, $SD = 2.04$) to instructed anticipation phase ($M = 5.25$, $SD = 2.26$), $F(1, 80) = 8.15$, $p = .005$, $\eta^2_{\text{partial}} = .092$, the difference between anticipation ($M = 7.32$, $SD = 2.01$) and instructed anticipation phase ($M = 6.85$, $SD = 2.17$) for participants in the positive group was not significant (see Figure 2), $F(1, 80) = 2.71$, p

= .103, η^2_{partial} = .033. These results failed to support our hypothesis that positive emotions may facilitate cognitive reappraisal.

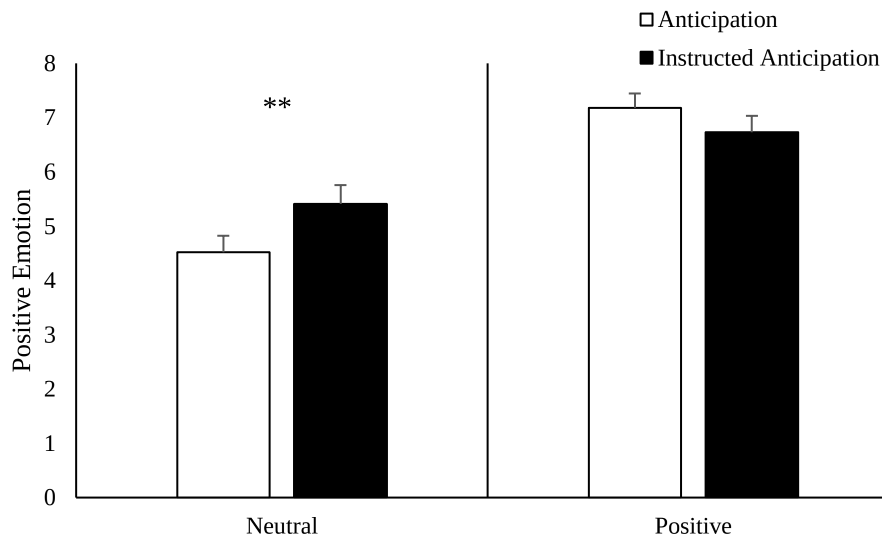

Figure 2. Self-reported positive emotion from anticipation to instructed anticipation phase. Error bars represent standard errors.

For negative emotion, neither the main effect of Emotion Induction, $F(1, 85)$ = 2.65, p = .107, η^2_{partial} = .030, nor the main effect of Phase, $F(1, 85)$ = .798, p = .374, η^2_{partial} = .009, was significant. In addition, the interaction of Emotion Induction and Phase was not significant, $F(1, 85)$ = .253, p = .616, η^2_{partial} = .003. The planned contrast investigating the changes across two phases for participants in the positive and neutral group was not significant as well, $t(85)$ = 0.51, p = .610.

To unravel the thought processes during anticipation and instructed anticipation period, we also performed two 2 (Emotion Induction: positive, neutral) x 2 (Phase: anticipation, instructed anticipation) repeated-measures ANOVAs, with Emotion

Induction as between-subjects variable, Phase as within-subjects variable, and the positive/negative ratings of thoughts about speech task as dependent variables.

For positive thoughts regarding the speech task, the main effect of Phase was significant, $F(1, 77) = 17.34$, $p < .001$, $\eta^2_{\text{partial}} = .184$, and participants engaged in more positive thoughts about the speech task when they were told to reinterpret the task (M = 5.13, SD = 2.15) than when they were given no instruction (M = 4.19, SD = 2.02), which was also true for both groups. However, the main effect of Emotion Induction and interaction of Phase and Emotion Induction were not significant, *p*s > .5, suggesting that participants in both groups generated more positive thoughts about speech task when they were instructed to do so, regardless of the virtual scenarios they were exploring (see Figure 3).

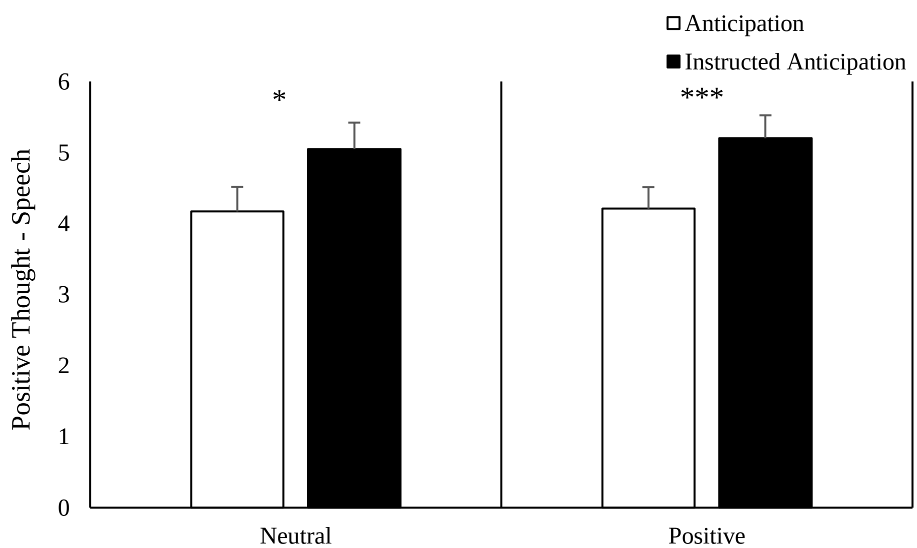

Figure 3. Positive thoughts about speech task for both groups. Error bars represent standard errors.

Similar to the results of positive thoughts, only the main effect of Phase was significant for negative thoughts about speech task, $F(1, 80) = 13.14$, $p = .001$, η^2_{partial}

= .141, and participants generated fewer negative thoughts during the instructed anticipation phase (*M* = 3.47, *SD* = 1.96) than anticipation phase (*M* = 4.28, *SD* = 2.24). The main effect of Emotion induction, the interaction of Emotion Induction and Phase, and the planned contrast across two phases were all non-significant, *p*s > .3. Taken together, we are quite certain that participants were able to follow instruction shown on the VR display to reinterpret the speech task in a positive manner, whereas being in an incidental positive context or not may be irrelevant for the generation of positive thoughts regarding the stressful event. In addition, evidence coming from analyses of thoughts failed to support our proposed facilitation effects of positive emotion on cognitive reappraisal.

Preregistered Exploratory Analyses

To capture participants' emotional changes throughout the entire experiment, we conducted two 2 (Emotion Induction: positive, neutral) x 5 (Phase: induction, anticipation, instructed anticipation, speech, recovery) mixed ANCOVA analyses, with Emotion Induction as between-subjects variable, Phase as within-subjects variable, emotional ratings at baseline as a covariate and self-reported positive and negative emotion as the dependent variables, respectively. For positive emotion, the main effect of Emotion Induction was significant, $F(1, 75) = 33.70$, $p < .001$, $\eta^2_{\text{partial}} = .310$, while the main effect of Phase was not significant, $F(4, 300) = 2.28$, $p = .061$, $\eta^2_{\text{partial}} = .029$. There was a significant interaction of Emotion Induction and Phase, $F(4, 300) = 9.06$, $p < .001$, $\eta^2_{\text{partial}} = .108$. Comparisons of simple effects revealed that participants in an incidental positive context reported more positive feelings at emotion induction, anticipation, instructed anticipation, recovery phases (see Figure 4) than those in a neutral context, all *ps* < .01, except that the difference of positive emotion between the positive and neutral group was not significant at the speech phase.

For negative emotion, the main effect of Emotion Induction was not significant, $F(1,81) = 0.71$, $p = .402$, $\eta^2_{\text{partial}} = .009$, but the main effect of Phase was significant, $F(4, 324) = 5.17$, $p < .001$, $\eta^2_{\text{partial}} = .060$. Also, the interaction of Emotion Induction and Phase was not significant at the .05 alpha level, $F(4, 324) = 2.10$, $p = .081$, $\eta^2_{\text{partial}} = .025$.

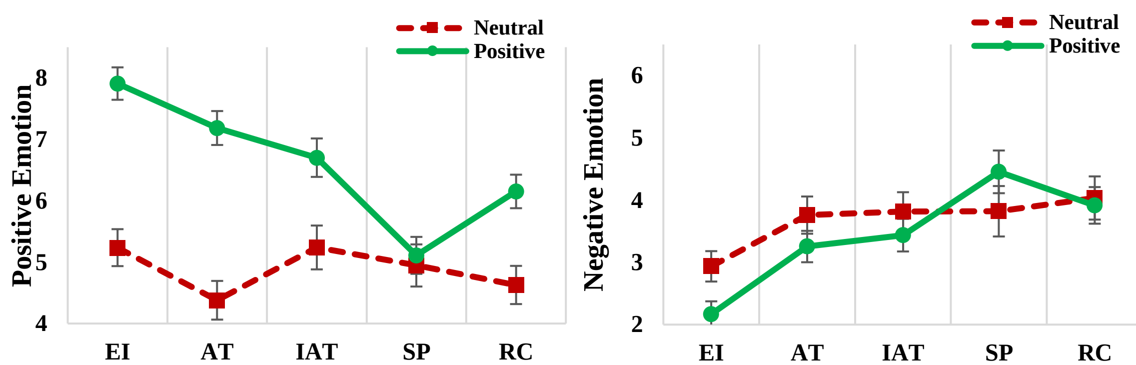

Figure 4. Emotional changes across difference phases. Error bars represent standard errors. EI is emotion induction phase. AT is anticipation phase. IAT is instructed anticipation phase. SP is speech phase. RC is recovery phase.

To capture the complete pattern and content of participants' thoughts, we analyzed the content of thoughts collected from the Thought Content Questionnaire to see whether being in an incidental positive context and using reappraisal to regulate stress will influence participants' positive or negative thoughts toward different thought target (i.e., speech task, virtual scenario). We performed a 2 (Emotion Induction: positive, neutral) x 2 (Phase: anticipation, instructed anticipation) x 2 (Thought Valence: positive, negative) x 2 (Thought Target: speech task, virtual scenario) repeated-measures ANOVA, with Emotion Induction as between-subjects variable, Phase, Thought Valence, and

Thought Target as within-subjects variables, and the ratings of thoughts as dependent variables. None of the main effects were significant. Also, the four-way interaction was not significant overall, $F(1, 64) = 0.96$, $p = .331$, $\eta^2_{\text{partial}} = .015$. However, both the three-way interaction of Thought Valence, Emotion Induction, and Target, $F(1, 64) = 24.51$, $p < .001$, $\eta^2_{\text{partial}} = .277$, and three-way interaction of Thought Valence, Phase, and Target, $F(1, 64) = 35.99$, $p < .001$, $\eta^2_{\text{partial}} = .360$, were significant. Two-way interaction of Thought Valence and Emotion Induction, $F(1, 64) = 12.82$, $p = .001$, $\eta^2_{\text{partial}} = .167$, and two-way interaction of Thought Valence and Phase, $F(1, 64) = 9.44$, $p = .003$, $\eta^2_{\text{partial}} = .128$, were also significant. Other three-way or two-way interactions were all non-significant.

Simple comparisons following the two-way interaction of Thought Valence and Emotion Induction revealed that participants in the neutral context had fewer positive thoughts, $F(1, 64) = 9.66$, $p = .003$, $\eta^2_{\text{partial}} = .131$, and more negative thoughts, $F(1, 64) = 6.73$, $p = .012$, $\eta^2_{\text{partial}} = .095$, than those in an incidental positive context. However, the relations between Thought Valence and Emotion Induction were different for Thought Target. Specifically, compared with those of the positive group, participants of the neutral group had fewer positive and more negative thoughts about VR, ps < .001, but had comparable positive and negative thoughts about the speech task, ps > .85.

Simple comparisons following the two-way interaction of Thought Valence and Phase showed that participants had a decrease in negative thoughts, $F(1, 64) = 5.09$, $p = .027$, $\eta^2_{\text{partial}} = .074$, and an increase in positive thoughts, $F(1, 64) = 7.17$, $p = .009$, $\eta^2_{\text{partial}} = .101$, from anticipation to instructed anticipation phase. Such relations between

Phase and Thought Valence only held true for thoughts about speech task, *p*s < .001. As for VR, both positive and negative thoughts about VR remained the same from anticipation to instructed anticipation phase, *p*s > .660.

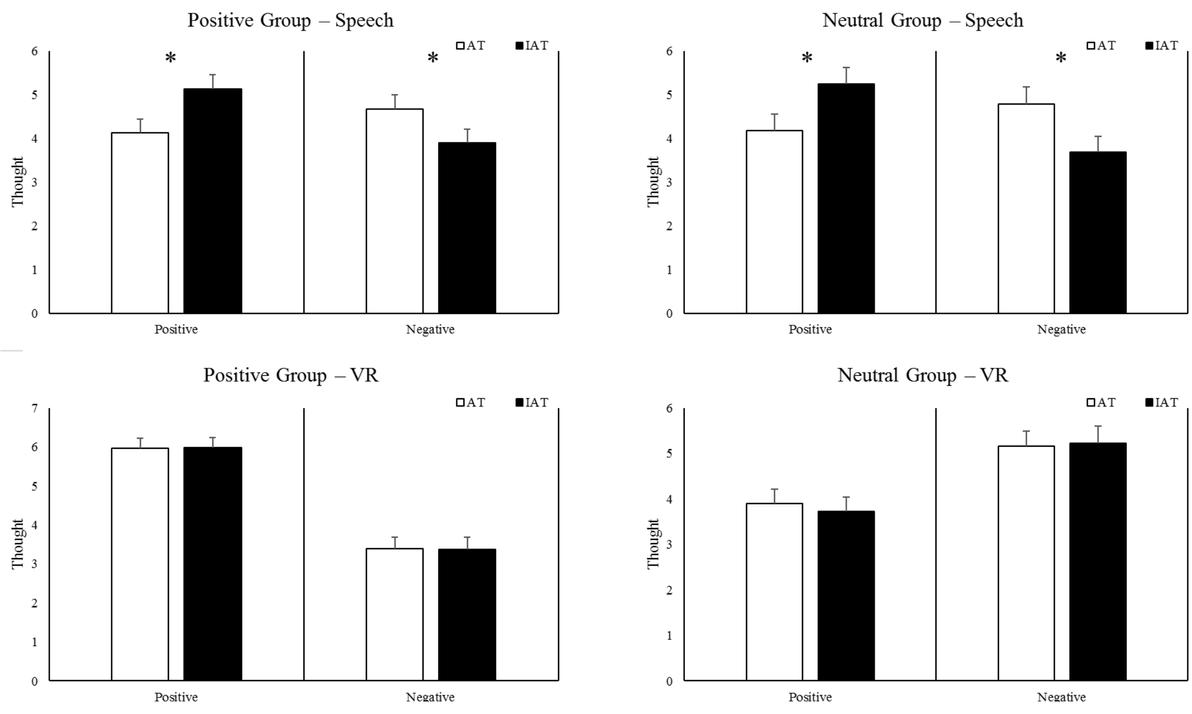

Figure 5. Positive and negative thoughts at anticipation and instructed anticipation phases. Error bars represent standard errors. AT is anticipation phase. IAT is instructed anticipation phase.

Non-Preregistered Exploratory Analyses

Analyses of other thoughts. Inconsistent with our hypothesis, the preregistered confirmatory and exploratory analyses indicated that positive emotion might not facilitate cognitive reappraisal. Participants in an incidental positive context engaged in as many positive thoughts about the upcoming stressful event as those in a neutral context did, while their overall emotional rating remained unchanged from anticipation to instructed anticipation phase. We speculated that participants in an incidental positive context were more likely to get distracted from the anticipation of a stressor, and the distraction may stem from their immersion in the VR and irrelevant thoughts they might have during the experiment. Additionally, the decrease of distraction from anticipation to instructed anticipation phase, resulting from cognitive reappraisal, may cancel out the positive impact brought by reappraisal. To test this speculation, we conducted two 2 (Emotion Induction: positive, neutral) x 2 (Phase: anticipation, instructed anticipation) repeated-measures ANOVAs, with thoughts about virtual scenarios and other thoughts irrelevant to speech task and VR as dependent variables, separately. For positive thoughts about VR, results indicated that the main effect of Phase, $F(1, 86) = 0.24$, $p = .624$, $\eta^2_{\text{partial}} = .003$, and the interaction of Emotion Induction and Phase, $F(1, 86) = 0.65$, $p = .421$, $\eta^2_{\text{partial}} = .008$, were not significant. However, the main effect of Emotion Induction was significant, $F(1, 86) = 38.34$, $p < .001$, $\eta^2_{\text{partial}} = .308$, and participants of the positive group ($M = 6.14$, $SD = 1.64$) had more positive thoughts about VR than those of the neutral group ($M = 3.96$, $SD = 1.63$).

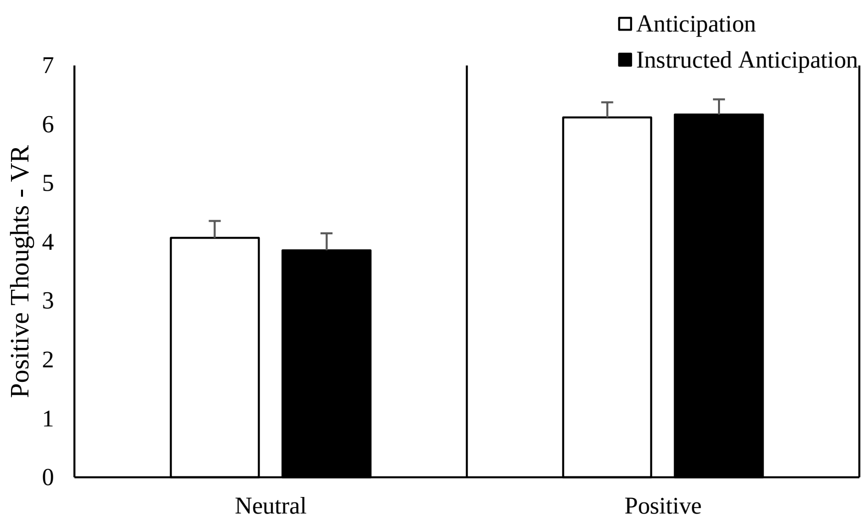

Figure 6. Positive thoughts about VR in anticipation and instructed anticipation phase. Error bars represent standard errors.

In terms of irrelevant thoughts, the main effect of Emotion Induction, $F(1, 75) = 0.35$, $p = .559$, $\eta^2_{\text{partial}} = .005$, and the main effect of Phase, $F(1, 75) = 2.64$, $p = .108$, $\eta^2_{\text{partial}} = .034$, were not significant. Although there was a tendency that participants in an incidental positive context had fewer irrelevant thoughts from anticipation to instructed anticipation phase, $F(1, 75) = 3.30$, $p = .073$, $\eta^2_{\text{partial}} = .042$, while participants in a neutral context had comparable amount of irrelevant thoughts across the two phases, $F(1, 75) = 0.687$, $p = .410$, $\eta^2_{\text{partial}} = .009$, the interaction of Emotion Induction and Phase was not significant (see Figure 7), $F(1, 75) = 3.36$, $p = .072$, $\eta^2_{\text{partial}} = .043$.

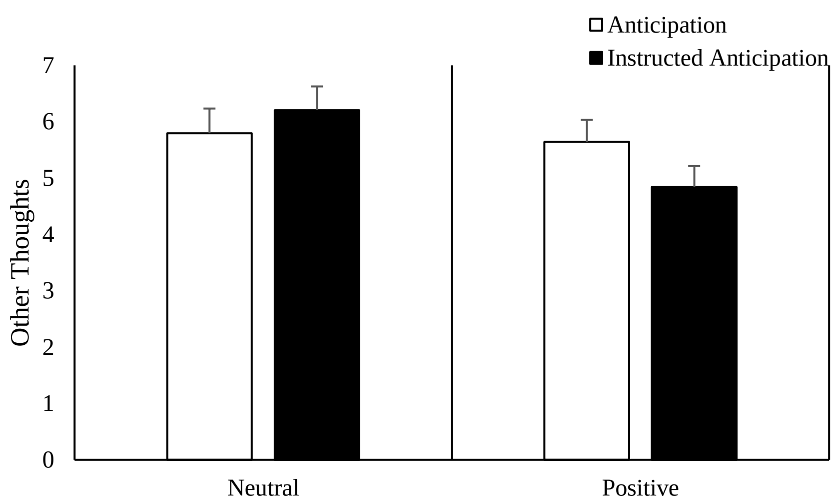

Figure 7. Other thoughts irrelevant to speech task and VR in anticipation and instructed anticipation phase. Error bars represent standard errors.

Moderated regression analysis. In addition to separate analyses of emotion and thoughts, we were also interested in the relations among emotion and thought at different phases. We mainly focused on positive emotions in the following analyses, taking into account that self-reported positive emotion was more sensitive in distinguishing differences between two groups than negative emotion. Specifically, we were interested in whether the change of thoughts after participants were instructed to reinterpret the speech task positively contributed to the change of positive emotion from anticipation to instructed anticipation phase. Hence, we first computed the increments of positive emotion and positive/negative thoughts about speech/VR (Increment of X = X at instructed anticipation phase – X at anticipation phase) and then calculated bivariate correlations among these increments of emotions and thoughts (see Table I).

Table 1.

Bivariate correlations between increments of emotions and thoughts

		IncPosVR	IncNegVR	IncPosSP	IncNegSP	IncOther
Neutral	IncPosEmo	.125	-.150	.042	-.396*	-.020
	N	35	37	30	31	29
Positive	IncPosEmo	.483**	-.100	.473**	-.552***	.252
	N	45	50	42	43	40

Note. IncPosE is the increment of positive emotion from anticipation to instructed anticipation phase. Similarly, IncPosVR is the increment of positive thought of VR; IncNegVR is the increment of negative thought of VR; IncPosSP is the increment of positive thought; IncNegSP is the increment of negative thought of speech task; IncOther is the increment of irrelevant thought.
* $p < .05$. ** $p < .01$. *** $p < .001$.

The possible moderating role of Emotion Induction was examined in a series of hierarchical regression analyses, including increments of emotion and thoughts in Step 1 before adding their interaction terms (Increment of thoughts × increment of positive emotion) in Step 2. We conducted hierarchical regression models for all five categories of thoughts, separately. The only significant moderation effect of Emotion Induction was found on the relation between the increment of positive thoughts about speech task and increment of positive emotion. As shown in Table II, the addition of interaction term at Step 2 added significant incremental variance, $R^2_{change} = .05$, F_{change} (1, 68) = 4.62, $p = .035$.

Table 2.

Results of moderated multiple regression models predicting increment of positive emotion with the condition as a moderator between increments of positive emotion and positive thoughts about speech task

Condition/ Predictors	*R*	Adj R^2	ΔR^2	*F*	β	*t*
Step 1	.467	.195	$.218^{***}$	9.61^{***}		
IncPosSP					.261	2.44^{*}
Emotion Induction					-1.574	-3.68^{***}
Step 2	.517	.235	$.050^{*}$	8.28^{***}		
IncPosSP					.295	2.79^{**}
Emotion Induction					-1.571	-3.77^{***}
IncPosSP x Emotion Induction					.450	2.15^{*}

Note. * $p < .05$. ** $p < .01$. *** $p < .001$.

For the neutral group, the increment of positive thoughts about speech task was not related to that of positive emotion, and the simple slope was not significantly different from zero, $b = .035$, $t(68) = .23$, $p = .817$. For the positive group, however, the increment of positive thoughts about speech task was positively related to that of positive emotion, and the simple slope was significantly different from zero, $b = .484$, $t(68) = 3.29$, $p < .01$, as can be seen in Figure 8. Results of the moderation effect indicated that when participants followed the instruction to reappraise the stressor, positive thoughts they generated may help them feel positive if they were in an incidental positive context.

In contrast, if they were in a neutral context, whether they generated more positive thoughts or not did not influence their positive feelings.

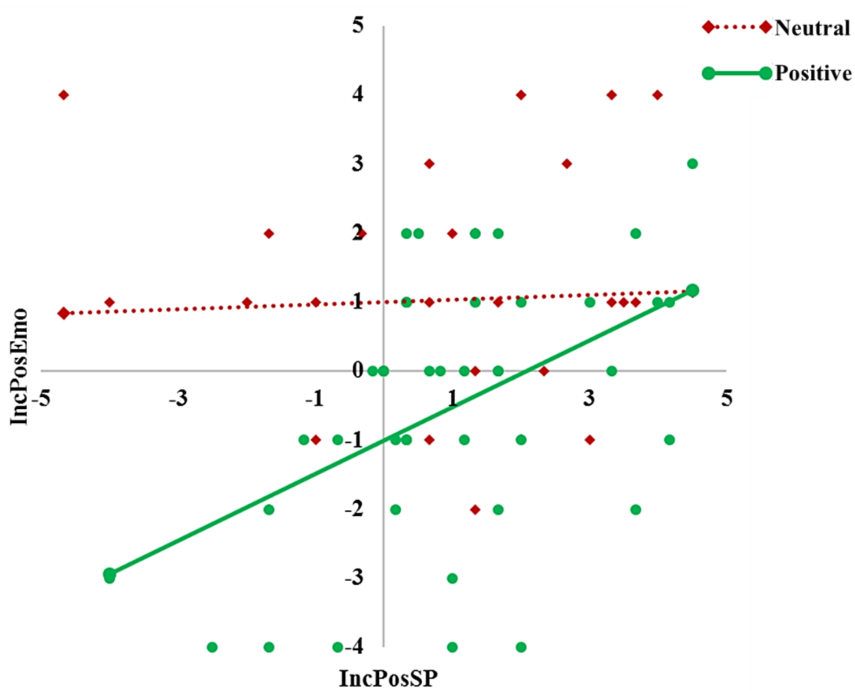

Figure 8. The increment of positive emotion regressed on increments of positive thoughts about speech task for the neutral and positive group.

DISCUSSION

We applied different virtual scenarios in inducing positive or neutral mood states in the present study, and the results demonstrated the effectiveness of VR. Compared with those in a neutral context, participants in an incidental positive context experienced more positive feelings across different phases when the virtual scenarios were available to them. However, during the speech phase when participants took off the VR headset and gave the speech in front of a judge, there was no difference in their emotional ratings.

Based on several different mechanisms we proposed that might support the facilitation effects of positive emotion on cognitive reappraisal, we hypothesized that compared with those in a neutral context, participants in an incidental positive context would report more positive emotion and less negative emotion when they were anticipating the speech task and instructed to reinterpret the stressor. However, results of confirmatory analyses failed to demonstrate that positive emotion facilitated cognitive reappraisal. In fact, participants of the positive group reported almost equivalent positive emotion at anticipation and instructed anticipation phases, while participants of the neutral group experienced a significant increase in positive emotion across the two phases. By analyzing the thoughts about speech task, we are certain that participants followed the instruction to reconsider the stressor in a positive way. Participants of both groups engaged in more positive and less negative thoughts about speech task at instructed anticipation phase compared with anticipation phase. However, being in an incidental positive context was not beneficial for generating more positive thoughts about speech task, implying that positive emotion may not facilitate reappraisal.

Such non-facilitation effects of positive emotion on cognitive reappraisal may result from the goal-oriented aspect of cognitive reappraisal. Cognitive reappraisal is a powerful goal-oriented regulatory strategy that can alleviate individuals' negative feelings and enhance their positive mood states at the same time (Hajcak & Nieuwenhuis, 2006; Kim & Hamann, 2007; McRae et al., 2010). It is possible that when individuals focus on their goal of changing the meaning of a stressful event, whether they are in a positive or neutral context may be irrelevant to the pursuit of the goal and such that the emotional contexts may have little influence on reappraisal. This plausible explanation is supported by the affect-as-information theory, which indicates that extraneous affect may exert an impact on information processing only when individuals believe the affect is relevant (Schwarz & Clore, 1983). When using reappraisal, the goal-oriented strategy, to regulate their emotional reactions, people may deem being in an incidental positive context as irrelevant and thus fail to infuse the effects of positive emotion into reinterpreting processes.

Regarding positive emotion during the anticipation and instructed anticipation phases, we did not expect that participants in an incidental positive context would report relatively equivalent positive emotions, while participants in a neutral group experienced more positive feelings during the instructed anticipation period. Given that participants of both groups followed the instruction to reappraise and increased positive thoughts could contribute to overall positive feelings, we speculated that participants in the positive context were more likely to get distracted from the stressor partly due to the positive virtual scenario they were exploring and irrelevant thoughts they generated, especially when they were not told to reinterpret the stressor (Dreisbach & Goschke, 2004).

Analyses of positive thoughts about the virtual scenario and other thoughts irrelevant to speech task and VR supported our speculation to some extent. For the positive group, positive thoughts about VR remained at the same level from anticipation to instructed anticipation phase, but irrelevant thoughts tended to drop across the two phases, while positive thoughts about speech task rose. Thus, the effects of cognitive reappraisal at instructed anticipation phase might be canceled out by the reduced effects of distraction, giving rise to unchanged emotional states across two phases. However, participants in a neutral context had comparable positive thought about VR and irrelevant thoughts across the two phases. Hence, trying to reconsider the stressor in a positive way may make them feel better.

An alternative explanation for the emotional changes from anticipation to instructed anticipation phase is that participants in a neutral context were more motivated to regulate the stressor and increase positive emotions than those in an incidental positive context. Existing literature implies that positive emotion may not always facilitate the use of reappraisal. In addition to the mechanisms we mentioned above, the mood-as-input account proposes that positive mood makes people feel satisfied with their performance and achievement they already have (Hawksley & Davey, 2010; Park & Banaji, 2000). Thus, compared with those in neutral mood states, people in positive mood states are less likely to put more effort in the processes of emotion regulation, which hinders the increase of positive emotion. In addition to the motivational account, some investigators propose that positive emotions do not broaden people's cognitive scope directly. Instead, positive emotions influence the balance between internal and external attention and adjust the mobilization of mental resource allocated between internal and external information

(Vanlessen, De Raedt, Koster, & Pourtois, 2016). Negative emotions trigger individuals' tendency toward a detail-oriented processing style, hindering the intake and processing of external new information (Clore & Palmer, 2009; Huntsinger, Isbell, & Clore, 2014). Positive emotions can trigger a transition from internal processing to external processing, facilitating the exploration and intake of external information. Such processes might be influenced by task demand. When the task is demanding, inward attention prevails, and processing of internal information is dominant. Taken together, when the demands of cognitive tasks are low and do not exceed cognitive resources, positive emotions can trigger the exploration of external information. However, when the tasks are more challenging, cognitive resources can be reoriented more to internal processes, such as cognitive control, by changing attentional mechanisms (Chun et al., 2011), and this guarantees proper resources can be utilized for task resolution. Notably, compared with positive moods, neutral mood favors the processes of internal information to a greater extent in both high and low cognitive demand. Given that reappraisal relies on internal processes and costs mental resources, implementation of this cognitively demanding strategy may be more successful in neutral mood states than in positive mood states, which implies the beneficial effects of neutral mood states rather than positive mood states. This may explain why participants in a neutral context experienced more positive emotion after they reappraised the stressor but not those in an incidental positive context.

Although results of our study failed to support the facilitation effects of positive emotion on cognitive reappraisal, we found that being in an incidental positive context facilitated the relation between increments of positive emotion and positive thoughts about speech task from anticipation to instructed anticipation phase. Specifically, participants of the positive group who generated more positive thoughts about speech task when they were told to reappraise were more likely to experience a greater increase in positive emotion. In contrast, the increase of positive thoughts about speech task was not associated with the increase of positive emotion among participants in a neutral context. Considerable research has shown that cognitive reappraisal facilitates the down-regulation of negative emotions, reflected by an increase in positive emotions (John & Gross, 2004; Ochsner & Gross, 2008). Therefore, it is not surprising to find the positive association between the increase of positive thoughts about speech and increase of positive emotion for participants of the positive group. Generating more positive thoughts about the stressor helped participants to experience more positive emotions, while such effects of reappraisal might be canceled out by the decrease of distraction, leading to unchanged emotional states from anticipation to instructed anticipation phase. On the contrary, the increase of positive thoughts about speech task failed to predict the increase of positive emotion in a neutral context, but participants of the neutral group did experience more positive feelings and engaged in more positive thoughts about speech task from anticipation to instructed anticipation phase. Unlike participants of the positive group, participants of the neutral group had almost equivalent positive thoughts about VR and irrelevant thoughts across the two phases. Taken all these facts into account, we suppose that the increase of positive emotion for the neutral group may not result from the effects of cognitive reappraisal but rather distraction. Participants exploring the neutral scenarios might get bored easily from emotion induction to anticipation phase. When they viewed the instruction to reappraise the stressor halfway through their anticipation of the speech task, they got something new to do and were likely to be distracted by the instruction. In such case, even though participants of the neutral group followed the instruction to generate more positive thoughts about speech task, their increase positive feelings originated from the distraction, resulting in an unrelated relation between the increase of positive emotion and increase of positive thoughts about speech across phases.

By drawing regression lines for each group, we also noticed that several participants of the positive group engaged in fewer positive thoughts about speech task and had less positive emotion when they stepped into the instructed anticipation phase, which bolstered the positive relationship between increments of thought and emotion for the positive group and let to overall no change between the two phases. Due to the time limit of our experiment, we were unable to assess participants' individual differences (e.g., resilience, trait reappraisal) and distinguish these participants from others. Future studies should measure these personality traits and investigate how this moderation effect of being in an incidental positive context on relations between the increase of positive emotion and positive thought may be influenced by individual difference.

In conclusion, being in an incidental positive context is conducive for individuals to increase their positive emotions. Participants generated more positive and fewer negative thoughts about speech task when they were instructed to reappraise, regardless of virtual scenarios they viewed. Although we hypothesized that positive emotion might facilitate cognitive reappraisal based on cognitive and motivational mechanisms we proposed, results of the present study failed to support the facilitation effects of positive emotion. However, being in an incidental positive context facilitated the relations between the increase of positive thoughts and increase of positive emotions. For those in an incidental positive context, an increase in positive thoughts about stressor during reappraisal period may give rise to an increase in positive emotion. However, the increase of positive thoughts was not related to the increase of positive emotion, which might result from distractions. Future investigation should explore the possible role of distractions and individual difference in the moderating effect of incidental emotional contexts.

REFERENCES

Andersen, S. L., & Teicher, M. H. (2009). Desperately driven and no brakes: Developmental stress exposure and subsequent risk for substance abuse. *Neuroscience & Biobehavioral Reviews*, *33*(4), 516–524. https://doi.org/10.1016/j.neubiorev.2008.09.009

APA. (2017). Stress in America press room. Retrieved April 28, 2018, from http://www.apa.org/news/press/releases/stress/index.aspx

Aschbacher, K., O'Donovan, A., Wolkowitz, O. M., Dhabhar, F. S., Su, Y., & Epel, E. (2013). Good stress, bad stress and oxidative stress: Insights from anticipatory cortisol reactivity. *Psychoneuroendocrinology*, *38*(9), 1698–1708. https://doi.org/10.1016/j.psyneuen.2013.02.004

Baños, R. M., Botella, C., Alcañiz, M., Liaño, V., Guerrero, B., & Rey, B. (2004). Immersion and emotion: Their impact on the sense of presence. *CyberPsychology & Behavior*, *7*(6), 734–741.

Bhanji, J. P., Kim, E. S., & Delgado, M. R. (2016). Perceived control alters the effect of acute stress on persistence. *Journal of Experimental Psychology: General*, *145*(3), 356–365. https://doi.org/10.1037/xge0000137

Bonanno, G. A., & Burton, C. L. (2013). Regulatory flexibility: An individual differences perspective on coping and emotion regulation. *Perspectives on Psychological Science*, *8*(6), 591–612.

Campos, A. C., Fogaca, M. V., Aguiar, D. C., Guimaraes, F. S., Campos, A. C., Fogaca, M. V., … Guimaraes, F. S. (2013). Animal models of anxiety disorders and stress. *Revista Brasileira de Psiquiatria*, *35*, S101–S111. https://doi.org/10.1590/1516-4446-2013-1139

Chermahini, S. A., & Hommel, B. (2012). Creative mood swings: Divergent and convergent thinking affect mood in opposite ways. *Psychological Research*, *76*(5), 634–640.

Chida, Y., & Steptoe, A. (2010). Greater cardiovascular responses to laboratory mental stress are associated with poor subsequent cardiovascular risk status. *Hypertension*, *55*(4), 1026–1032.

Chun, M. M., Golomb, J. D., & Turk-Browne, N. B. (2011). A taxonomy of external and internal attention. *Annual Review of Psychology*, *62*(1), 73–101. https://doi.org/10.1146/annurev.psych.093008.100427

Clore, G. L., & Palmer, J. (2009). Affective guidance of intelligent agents: How emotion controls cognition. *Cognitive Systems Research, 10*(1), 21–30.

Davidson, K. W., Mostofsky, E., & Whang, W. (2010). Don't worry, be happy: Positive affect and reduced 10-year incident coronary heart disease: The Canadian Nova Scotia Health Survey. *European Heart Journal, 31*(9), 1065–1070. https://doi.org/10.1093/eurheartj/ehp603

Dreisbach, G., & Goschke, T. (2004). How positive affect modulates cognitive control: Reduced perseveration at the cost of increased distractibility. *Journal of Experimental Psychology-Learning Memory and Cognition*, *30*(2), 343–352.

Estupiñán, S., Rebelo, F., Noriega, P., Ferreira, C., & Duarte, E. (2014). Can virtual reality increase emotional responses (arousal and valence)? A pilot study. In A. Marcus (Ed.), *International conference of design, user experience, and usability* (pp. 541–549). Springer.

Felnhofer, A., Kothgassner, O. D., Schmidt, M., Heinzle, A.-K., Beutl, L., Hlavacs, H., & Kryspin-Exner, I. (2015). Is virtual reality emotionally arousing? Investigating five emotion inducing virtual park scenarios. *International Journal of Human-Computer Studies*, *82*, 48–56.

Folkman, S. (2008). The case for positive emotions in the stress process. *Anxiety, Stress, & Coping*, *21*(1), 3–14. https://doi.org/10.1080/10615800701740457

Folkman, S. (2013). Stress: Appraisal and coping. In M. D. Gellman & J. R. Turner (Eds.), *Encyclopedia of behavioral medicine* (pp. 1913–1915). Springer. Retrieved from http://link.springer.com/10.1007/978-1-4419-1005-9_215

Folkman, S., & Moskowitz, J. T. (2000). Stress, positive emotion, and coping. *Current Directions in Psychological Science*, *9*(4), 115–118.

Franconeri, S. L., Alvarez, G. A., & Cavanagh, P. (2013). Flexible cognitive resources: Competitive content maps for attention and memory. *Trends in Cognitive Sciences*, *17*(3), 134–141. https://doi.org/10.1016/j.tics.2013.01.010

Fredrickson, B. L. (1998). What good are positive emotions? *Review of General Psychology*, *2*(3), 300.

Fredrickson, B. L. (2004). The broaden-and-build theory of positive emotions. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *359*(1449), 1367.

Fröber, K., & Dreisbach, G. (2014). The differential influences of positive affect, random reward, and performance-contingent reward on cognitive control. *Cognitive, Affective, & Behavioral Neuroscience*, *14*(2), 530–547.

Gervais, M., & Wilson, D. S. (2005). The evolution and functions of laughter and humor: A synthetic approach. *The Quarterly Review of Biology*, *80*(4), 395–430. https://doi.org/10.1086/498281

Hajcak, G., & Nieuwenhuis, S. (2006). Reappraisal modulates the electrocortical response to unpleasant pictures. *Cognitive, Affective, & Behavioral Neuroscience*, *6*(4), 291–297.

Hawksley, J., & Davey, G. C. L. (2010). Mood-as-input and depressive rumination. *Behaviour Research and Therapy*, *48*(2), 134–140. https://doi.org/10.1016/j.brat.2009.10.004

Heth, J. T., & Somer, E. (2002). Characterizing stress tolerance: “Controllability awareness” and its relationship to perceived stress and reported health. *Personality and Individual Differences*, *33*(6), 883–895. https://doi.org/10.1016/S0191-8869(01)00198-2

Hirt, E. R., Devers, E. E., & McCrea, S. M. (2008). I want to be creative: Exploring the role of hedonic contingency theory in the positive mood-cognitive flexibility link. *Journal of Personality and Social Psychology*, *94*(2), 214.

Huntsinger, J. R., Isbell, L. M., & Clore, G. L. (2014). The affective control of thought: Malleable, not fixed. *Psychological Review*, *121*(4), 600.

Hupont, I., Gracia, J., Sanagustin, L., & Gracia, M. A. (2015). How do new visual immersive systems influence gaming QoE? A use case of serious gaming with Oculus Rift. In *Quality of Multimedia Experience (QoMEX), 2015 Seventh International Workshop on* (pp. 1–6). IEEE.

Isen, A. M. (2008). Some ways in which positive affect influences decision making and problem solving. *Handbook of Emotions*, *3*, 548–573.

John, O. P., & Gross, J. J. (2004). Healthy and unhealthy emotion regulation: Personality processes, individual differences, and life span development. *Journal of Personality*, *72*(6), 1301–1334. https://doi.org/10.1111/j.1467-6494.2004.00298.x

Johnson, D. R. (2009). Emotional attention set-shifting and its relationship to anxiety and emotion regulation. *Emotion*, *9*(5), 681.

Kalisch, R., Müller, M. B., & Tüscher, O. (2015). A conceptual framework for the neurobiological study of resilience. *Behavioral and Brain Sciences*, *38*. Retrieved from https://www.cambridge.org/core/services/aop-cambridge-core/content/view/2DABC76D4D8F97EF215A8DC7D9C85F2A/S0140525X14001745a.pdf/ppw.kuleuven.be/clep

Kent, M., Davis, M. C., & Reich, J. W. (2013). *The resilience handbook: Approaches to stress and trauma*. Routledge.

Kim, S. H., & Hamann, S. (2007). Neural correlates of positive and negative emotion regulation. *Journal of Cognitive Neuroscience*, *19*(5), 776–798.

Kirby, E. D., Muroy, S. E., Sun, W. G., Covarrubias, D., Leong, M. J., Barchas, L. A., & Kaufer, D. (2013). Acute stress enhances adult rat hippocampal neurogenesis and activation of newborn neurons via secreted astrocytic FGF2. *Elife*, *2*.

Lerner, J. S., Li, Y., Valdesolo, P., & Kassam, K. S. (2015). Emotion and decision making. *Annual Review of Psychology*, *66*.

Malooly, A. M., Genet, J. J., & Siemer, M. (2013). Individual differences in reappraisal effectiveness: The role of affective flexibility. *Emotion*, *13*(2), 302.

McNally, R. J., Robinaugh, D. J., Wu, G. W. Y., Wang, L., Deserno, M. K., & Borsboom, D. (2015). Mental disorders as causal systems: A network approach to posttraumatic stress disorder. *Clinical Psychological Science*, *3*(6), 836–849. https://doi.org/10.1177/2167702614553230

McRae, K., Ciesielski, B., & Gross, J. J. (2012). Unpacking cognitive reappraisal: goals, tactics, and outcomes. *Emotion*, *12*(2), 250.

McRae, K., Hughes, B., Chopra, S., Gabrieli, J. D., Gross, J. J., & Ochsner, K. N. (2010). The neural bases of distraction and reappraisal. *Journal of Cognitive Neuroscience*, *22*(2), 248–262.

McRae, K., Jacobs, S. E., Ray, R. D., John, O. P., & Gross, J. J. (2012). Individual differences in reappraisal ability: Links to reappraisal frequency, well-being, and cognitive control. *Journal of Research in Personality*, *46*(1), 2–7. https://doi.org/10.1016/j.jrp.2011.10.003

Ochsner, K. N., & Gross, J. J. (2008). Cognitive emotion regulation: Insights from social cognitive and affective neuroscience. *Current Directions in Psychological Science*, *17*(2), 153–158. https://doi.org/10.1111/j.1467-8721.2008.00566.x

Okely, J. A., Weiss, A., & Gale, C. R. (2017). The interaction between stress and positive affect in predicting mortality. *Journal of Psychosomatic Research*, *100*, 53–60.

Park, J., & Banaji, M. R. (2000). Mood and heuristics: The influence of happy and sad states on sensitivity and bias in stereotyping. *Journal of Personality and Social Psychology*, *78*(6), 1005.

Price, M., Mehta, N., Tone, E. B., & Anderson, P. L. (2011). Does engagement with exposure yield better outcomes? Components of presence as a predictor of treatment response for virtual reality exposure therapy for social phobia. *Journal of Anxiety Disorders*, *25*(6), 763–770.

Quick, J. C., Cooper, C. L., Nelson, D. L., Quick, J. D., & Gavin, J. H. (2003). Stress, health, and well-being at work. In J. Greenberg (Eds.), *Organizational behavior: The state of science* (pp. 53-89). Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Quigley, B. M., & Tedeschi, J. T. (1996). Mediating effects of blame attributions on feelings of anger. *Personality and Social Psychology Bulletin*, *22*(12), 1280–1288.

Riva, G., Mantovani, F., Capideville, C. S., Preziosa, A., Morganti, F., Villani, D., … Alcañiz, M. (2007). Affective interactions using virtual reality: The link between presence and emotions. *CyberPsychology & Behavior*, *10*(1), 45–56.

Schmeichel, B. J., & Demaree, H. A. (2010). Working memory capacity and spontaneous emotion regulation: High capacity predicts self-enhancement in response to negative feedback. *Emotion*, *10*(5), 739.

Schmeichel, B. J., & Tang, D. (2015). Individual differences in executive functioning and their relationship to emotional processes and responses. *Current Directions in Psychological Science*, *24*(2), 93–98. https://doi.org/10.1177/0963721414555178

Schuemie, M. J., Van Der Straaten, P., Krijn, M., & Van Der Mast, C. A. (2001). Research on presence in virtual reality: A survey. *CyberPsychology & Behavior*, *4*(2), 183–201.

Schwarz, N., & Clore, G. L. (1983). Mood, misattribution, and judgments of well-being: Informative and directive functions of affective states. *Journal of Personality and Social Psychology*, *45*(3), 513.

Seery, M. D., Leo, R. J., Holman, E. A., & Silver, R. C. (2010). Lifetime exposure to adversity predicts functional impairment and healthcare utilization among individuals with chronic back pain. *Pain*, *150*(3), 507–515.

Sheppes, G., & Meiran, N. (2008). Divergent cognitive costs for online forms of reappraisal and distraction. *Emotion*, *8*(6), 870–874. https://doi.org/10.1037/a0013711

Shiota, M. N., & Levenson, R. W. (2009). Effects of aging on experimentally instructed detached reappraisal, positive reappraisal, and emotional behavior suppression. *Psychology and Aging*, *24*(4), 890–900. https://doi.org/10.1037/a0017896

Shiota, M. N., & Levenson, R. W. (2012). Turn down the volume or change the channel? Emotional effects of detached versus positive reappraisal. *Journal of Personality and Social Psychology*, *103*(3), 416.

Tice, D. M., Baumeister, R. F., Shmueli, D., & Muraven, M. (2007). Restoring the self: Positive affect helps improve self-regulation following ego depletion. *Journal of Experimental Social Psychology*, *43*(3), 379–384. https://doi.org/10.1016/j.jesp.2006.05.007

Toet, A., van Welie, M., & Houtkamp, J. (2009). Is a dark virtual environment scary? *CyberPsychology & Behavior*, *12*(4), 363–371.

Troy, A. S., Shallcross, A. J., & Mauss, I. B. (2013). A person-by-situation approach to emotion regulation: Cognitive reappraisal can either help or hurt, depending on the context. *Psychological Science*, *24*(12), 2505–2514.

Tugade, M. M., & Fredrickson, B. L. (2007). Regulation of positive emotions: Emotion regulation strategies that promote resilience. *Journal of Happiness Studies*, *8*(3), 311–333. https://doi.org/10.1007/s10902-006-9015-4

Vanlessen, N., De Raedt, R., Koster, E. H., & Pourtois, G. (2016). Happy heart, smiling eyes: A systematic review of positive mood effects on broadening of visuospatial attention. *Neuroscience & Biobehavioral Reviews*, *68*, 816–837.

Vanlessen, N., Rossi, V., Raedt, R. D., & Pourtois, G. (2013). Positive emotion broadens attention focus through decreased position-specific spatial encoding in early visual cortex: Evidence from ERPs. *Cognitive, Affective, & Behavioral Neuroscience*, *13*(1), 60–79. https://doi.org/10.3758/s13415-012-0130-x

Visch, V. T., Tan, E. S., & Molenaar, D. (2010). The emotional and cognitive effect of immersion in film viewing. *Cognition and Emotion*, *24*(8), 1439–1445.

Waugh, C. E., Panage, S., Mendes, W. B., & Gotlib, I. H. (2010). Cardiovascular and affective recovery from anticipatory threat. *Biological Psychology*, *84*(2), 169–175.

Webb, T. L., Miles, E., & Sheeran, P. (2012). Dealing with feeling: A meta-analysis of the effectiveness of strategies derived from the process model of emotion regulation. *Psychological Bulletin*, *138*(4), 775.

Yang, X., Garcia, K. M., Jung, Y., Whitlow, C. T., McRae, K., & Waugh, C. E. (2018). vmPFC activation during a stressor predicts positive emotions during stress recovery. *Social Cognitive and Affective Neuroscience*, *13*(3), 256–268.

APPENDIX

Questionnaire A (only used at anticipation phase)

We are interested in what thoughts you might have had in last couple of minutes while you were exploring the virtual scenario after you knew you were going to give an impromptu speech. Please read the following statements and indicate how much time you engaged in these thoughts while you were viewing the scenario. Please try as much as possible to indicate

1. I had pleasant thoughts about the content of the virtual scenario.
2. I had unpleasant thoughts about the content of the virtual scenario.
3. I thought that the virtual scenario was calming.
4. I thought that the virtual scenario was boring.
5. I thought that the virtual scenario was exciting.
6. I thought that the virtual scenario was annoying.
7. I had mostly positive thoughts about the upcoming speech task.
8. I had mostly negative thoughts about the upcoming speech task.
9. I thought about how frustrated I was with the upcoming speech task.
10. I thought about how stressful I was with the upcoming speech task.
11. I thought about how fine I was with the upcoming speech task.
12. I thought about how content I was with the upcoming speech task.
13. I thought about things unrelated to the upcoming speech task or the virtual scenario.
14. I thought about other things besides this experiment.

Questionnaire B (only used at instructed anticipation phase)

We are interested in what thoughts you might have had in last couple of minutes after you were told to “reinterpret or re-consider the upcoming speech task so that you feel as positive as you can” while you kept exploring the virtual scenario. Please read the following statements and indicate how much time you engaged in these thoughts while you were viewing the scenario. Please try as much as possible to indicate

1. I had pleasant thoughts about the content of the virtual scenario.
2. I had unpleasant thoughts about the content of the virtual scenario.
3. I thought that the virtual scenario was calming.
4. I thought that the virtual scenario was boring.
5. I thought that the virtual scenario was exciting.
6. I thought that the virtual scenario was annoying.
7. I had mostly positive thoughts about the upcoming speech task.
8. I had mostly negative thoughts about the upcoming speech task.
9. I thought about how frustrated I was with the upcoming speech task.
10. I thought about how stressful I was with the upcoming speech task.
11. I thought about how fine I was with the upcoming speech task.
12. I thought about how content I was with the upcoming speech task.
13. I thought about things unrelated to the upcoming speech task or the virtual scenario.
14. I thought about other things besides this experiment.

CURRICULUM VITAE

Lauren Yu Song

Department of Psychology
Wake Forest University, Winston-Salem, United States
Tel: 336-934-0743 E-mail: lauren.yusong@gmail.com

EDUCATIONAL BACKGROUND

Wake Forest University Winston -Salem, United States
Master of Arts in Psychology 09/2016 – 05/2018 (expected)

- GPA: 3.68/4.0
- First Year Project: The Role of Positive Emotion on Cognitive Reappraisal
- Master Thesis: The Effects of Positive Emotion on Cognitive Reappraisal (forthcoming)

Peking University Beijing, China
Bachelor of Science in Psychology 09/2012 - 07/2016 (expected)

- GPA: 3.72/4.0 (rank 2nd in the grade); admitted on the basis of performance on national college admissions exam (top 0.001%)
- Selected awards and scholarships: Robin Li Yanhong Scholarship (top 5% of the grade, awarded to those with outstanding academic performance),Wu-Si Scholarship for academic excellence, National Undergraduate Research Fellowship (top 5% of all second-year students at Peking University, on the basis of outstanding research performance), Peking University's Excellent Student Leader of the Year Award

Bachelor of Arts in Economics 09/2013 - 07/2016 (expected)

- Admitted to the Economics Program at the National School of Development, which has an acceptance rate less than 20% for Peking University students
- Coursework: behavioral economics; econometrics

University of Toronto Toronto, Canada
Exchange Student 09/2014 – 12/2014

- GPA: 3.53/4.0
- Scholarship: CSC (China Scholarship Council) Scholarship for Outstanding Undergraduate Student (top 1%, awarded to those with overall outstanding performance)

RESEARCH EXPERIENCE

Affective Neuroscience Winston -Salem, United States

Emolab, Wake Forest University Advisor: Dr. Christian Waugh

The Effects of Positive Emotion on Cognitive Reappraisal 08/2016 - present

- Reviewed literature on positive emotions and cognitive reappraisal.
- Conducted behavioral studies measuring behavioral and physiological indicators of positive and negative emotion to investigate how positive emotions may facilitate cognitive reappraisal

- Revised experiment design, recruited participants from undergraduate psychology subject pool and MTurk, performed experiments in lab and on Qualtrics, analyzed data and wrote up results.
- Trained on comprehensive psychophysiological tools, trained undergraduate RAs and assisted with IRB communications.

Social Neuroscience Beijing, China

Center for Brain and Cognitive Sciences, Peking University Advisor: Dr. Xiaolin Zhou

The Influence of Cooperative Priming and Social Status on Cooperative Behavior
02/2016 - 06/2016

- Analyzed how being endowed with different social statuses in a math competition and competitive and cooperative priming affects cooperative behavior in the centipede game.
- Found that when participants interacted with high-status players, they are more likely to exit earlier compared with low-status players. Social status and competitive and cooperative priming both affect our cooperative behavior. Individuals behave more competitively or more cooperatively when they interact with high-status players or low-status players respectively. Competitive and cooperative priming promotes competitive or cooperative behavior depending on which orientation are primed. In contrast to the interaction with low-status players, the effects of competitive and cooperative priming are enlarged when interacting with high-status players.
- Wrote a Matlab program to implement the interactive game; analyzed data using SPSS.

Propagation of gratitude regulated by interpersonal distance 05/2015 - 03/2016

- Designed an interactive game in which participants were first informed of their partner's choice (sharing pain with them or not) and then secretly transferred an amount of money (i.e., repayment) to the partner, the partner's friend, or a stranger, and then rated the extent to which they felt gratitude toward the person to whom payment could be sent for that particular round; used Self- and Other-Interest Inventory (SOII) and Interpersonal Reactive Index (IRI-C) to investigate personality differences related to gratitude and prosocial behavior.
- Found that participants who were informed that their partner chose to share in their pain exhibited significant decreases in the amount of money they transferred and their feelings of gratitude when interpersonal distance increased. Self- and other-interest scores contributed independently to the prediction of prosocial behavior, and IRI was significantly correlated with decay of gratitude rating.
- Wrote a Matlab program to implement the interactive game; analyzed data using SPSS.

The effect of different expressions of gratitude on benefactors 02/2015 - 05/2015

- Created an interactive game during which participants (the real benefactors) could assist fictitious help-seekers to manipulate expressions of gratitude (i.e., monetary or nonmonetary gratitude); measured benefactors' communal and exchange orientations; recorded participant's prosocial behavior and willingness to continue relationships. The aim was to address how different ways of expressing gratitude interact with personal relationship orientation to influence benefactors.
- Wrote Matlab programs to implement the interactive game; recruited college students via different university-wide websites

Social and Personality Psychology Beijing, China

Mental Health Education and Counseling Center, Peking University

Advisor: Dr. Liu Haihua, Director of the Mental Health Education and Counseling Center

Prediction of users' emotions and personalities in social network 10/2015 - present

- Aim is to create a model to predict emotions and personalities of users from various social networking sites based on the content of their posts. Identified emotions that are (found to be) highly related to performance on social networks through a review of the existing literature, recruited participants to rate emotional states revealed by every post via a 5-point Likert scale, will use Ten Item Personality Inventory (TIPI-C) to measure users' personality, and will apply machine learning algorithms to analyze social network users' posts.

Cognitive Psychology Beijing, China

Center for Brain and Cognitive Sciences, Peking University Advisor: Dr. Xiaolin Zhou

The effect of non-native accent on semantic processing in comprehension 11/2012 - 06/2013

- Recorded sentences read by native and non-native English speakers using professional recording equipment, and used Praat to edit audio materials.
- Recruited native English speakers from several universities, explained experiment requirements and tasks to participants, assisted the experimenter with ERP study, and debriefed participants at the end of the study.

Department of Psychology, Peking University Advisor: Professor Yanhong Wu

Validity of standardized English proficiency test in China 09/2013 - 12/2013

- Modified the Chinese-English bilingual Stroop task by setting four keys to press for each color (with neutral, congruent, and incongruent conditions), displayed a combination of Chinese characters and English words on the screen, instructed participants to press predefined keys when the corresponding stimuli were displayed, recorded their reaction times and accuracy rates, and collected their scores on the Chinese College English Test Band Four (CET-4) and TOEFL. The results indicate that, compared to the TOEFL, the correlation between participants' scores on the CET-4 and their reaction time was negligible, which suggested that the CET-4 may not be a valid means of determining English proficiency.
- Wrote a Presentation program to present stimuli of the bilingual Stroop task; gathered data from Chinese students at Peking University; analyzed data using SPSS.

Clinical Psychology Beijing, China

Department of Psychology, Peking University Advisor: Professor Mingyi Qian

Affective priming effect of positive faces in high social anxiety individuals

03/2013 – 06/2013

- Reviewed the existing literature, reported the latest research advances made in the study of social anxiety in lab meetings, and provided ways of improving the experimental design.
- Took pictures of faces displaying positive or negative affective states, and edited photos using Photoshop; assisted the experimenter in the execution of an eye tracking experiment.

Interdisciplinary Study Beijing, China

Department of Sociology & College of Urban and Environmental Sciences, PKU

Impact of isomorphic urban space on social media 12/2013 – 05/2014

- Proposed underlying factors from a psychological perspective that could exert an impact on personal attitude and individual behavior toward different types of social media based on an examination of the existing literature; also designed questionnaires to investigate users' motivation, experience, and behavior related to social media, and distributed over 200 questionnaires online.
- Gathered data from users who were familiar with popular domestic social media, including Weibo, Douban, Baidu Tieba, and Renren; conducted reliability analysis and factor analysis using SPSS.

ADDITIONAL EXPERIENCE

Mindfulness-Based Stress Reduction Program, Peking University 05/2015 – 07/2015

Participant

- Completed in the Mindfulness-Based Stress Reduction program (MBSR)
- Learned mindfulness meditation in an eight-week intensive workshop that involved weekly group meetings and homework, which was instructed by Dr. Liu Haihua, Director of the Mental Health Education and Counseling Center.

Center for Brain and Cognitive Sciences, Peking University 02/2015 – 03/2015

Translator

- Translated Chapter 9 of *Social Cognition: From brains to culture*[2] from English to Chinese
- Proofread to ensure that the translations conveyed all information accurately and explicitly while adhering to its original style.

Global Youth Leadership Program, HK Polytechnic University and Peking University

06/2013 – 02/2015

Delegate

- Honored as one of the 24 Peking University delegates selected from nearly 200 applicants. Completed a course on leadership, visited corporations (e.g., Tencent, the Voice of America) and institutions (e.g., UNICEF, UNDP, Legislative council of the HKSAR), and attended talks featuring leaders from various fields.
- Investigated China's poverty alleviation policies under the supervision of Professor Yuegen Xiong, experienced absolute poverty in rural areas of Western China and relative poverty in Sham Shui Po, Hong Kong, and gave a speech at the Youth Forum on Poverty in Hong Kong and Mainland China.
- Taught children with HIV certain basic skills (e.g., cooperate, turn their trash into treasure) in the Rainbow Bridge Orphanage, Cambodia, and used psychological theories and principles to organize activities aiming to cultivate love and hope in their lives.

---

[2] Fiske, S. T., & Taylor, S. E. (2013). Cognitive structures of attitudes. In M. Carmichael (Eds.), *Social cognition: From brains to culture* (pp. 232-256). London, England: Sage Publications.

- Discussed the social welfare system of America with Professors from Columbia University, Fordham University, and Georgetown University; the experience inspired me to explore the underpinning of well-being and the use of psychology to change the world.

TEACHING EXPERIENCE

Department of Psychology, Wake Forest University 08/2017 – 05/2018

Teaching Assistant

- Course: Human Cognition
- Instructor: Dr. Janine Jennings
- Duties: Graded tests

Department of Psychology, Wake Forest University 08/2017 – 05/2018

Teaching Assistant

- Course:Human Sexuality
- Instructor: Dr. Philip Batten
- Duties: Graded tests, and summarized tests

Department of Psychology, Peking University 03/2015 – 07/2015

Teaching Assistant

- Course: Consumer Behavior
- Instructor: Dr. Tong Jiajin
- Duties: Designing tests, assigning class participation marks, holding class discussions, and updating course materials online

PRESENTATION

Song, Y., & Waugh, C. (2018, January). *The effects of positive emotion on cognitive reappraisal*. Talk presented at Wake Forest University Psychology Department in Seminar in Self-Regulation.

Song, Y., Hao, L., & Wu, Y. (2014, May) *"Bilingual stroop in Chinese speakers with English as a second language: Exploring the validity of the English language testing system in China.* Poster presented at the Mainland, Taiwan and Hong Kong Psychology Student Research Symposium at Peking University, Beijing, China, 2014

PROFESSIONAL ASSOCIATION

- Association for Psychological Science 2016 - 2018
- Chinese Psychological Society 2014 - 2016

PROFESSIONAL SKILLS

Computer and Language Skills

- Programing: C, Matlab, Presentation
- Software: SPSS, R, Microsoft Office suite, Praat, Photoshop, Visual, XMind
- Languages: Chinese - Mandarin (Native), English (fluent)

Interests

- Playing the erhu (performer at Peking University Chinese Orchestra), squash, tennis, reading, traveling