AN EXAMINATION OF EMOTION IN SOCIAL AND COGNITIVE PROCESSES

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AN EXAMINATION OF EMOTION IN SOCIAL AND COGNITIVE PROCESSES

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Abstract

Chapter 1 compared two lines of research that have examined the effects of cognitive load on emotions. One has shown that the emotions elicited by passive viewing of emotional images are reduced by cognitive load. Another has shown that, when maintained, emotions are not reduced by cognitive load. Participants either passively viewed, or maintained the emotions elicited by, negative emotional images, and after a delay rated their emotional intensity. Half of trials included cognitive load during the delay. Results showed cognitive load reduced emotional intensity during passive-viewing, but not during emotion maintenance. The present study replicates the both previous findings, showing the key factor is whether or not emotions are maintained.

Chapter 1's results suggested high trait positive affect may be associated with higher intensity negative emotions, relative to low trait positive affect. Chapter 2 tested this idea with data from two samples. Participants self-reported either state-level (Sample 1) or trait-level affect (Sample 2). Then each participant performed a task that involved viewing negative emotional images, and rating the images' emotional intensity. Results indicated both state negative affect (Sample 1) and trait positive affect (Sample 2) correlated positively with image intensity ratings. The state negative affect

finding is consistent with previous mood congruence research. The trait positive affect finding is consistent with Chapter 1, though a full understanding will require further research.

Chapter 3 evaluated whether the shortage of Millennial students pursuing STEM is associated with their preference for work/life-interaction—a preference inconsistent with traditional science careers. We created two lab recruitment videos depicting contrasting approaches to running STEM labs and training students: A *work-focused* video and a *work/life-interaction-focused* video. In Study 3.1, current professors rated the videos, and confirmed the two videos reflected real-world differences in training approaches. In Study 3.2, current STEM students watched one of the two videos, and completed surveys. The *work/life-interaction-focused* video participants reported a greater *sense of belonging* to and *desire to participate* in the lab, relative to the *work-focused* video participants. This suggests Millennials possess a strong desire for work/life-interaction, which runs counter to the traditional lab-training model.

BIOGRAPHICAL SKETCH

Will DeFraine stayed in school for a really long time, save for the brief period he spent driving battle tanks for the Army that ended unceremoniously. This dissertation was the last bit of schoolwork he ever had to complete, and for which Cornell University ceremoniously awarded him a Ph.D. degree. Afterwards, he probably used his degree to get a job—the money from which he used to pay for his already-completed schooling in an amount substantially higher than the actual cost.

Will and his wife went on to spend as much time as possible traveling the world, exploring its cities and remaining wildernesses alike. They also went on to have many children, all of whom, sadly, were born without thumbs, had relatively short lives, and never learned any languages. Their children's condition rendered them unsuitable for traveling with Will and his wife. But the children never seemed to mind being left alone, since they were provided with adequate food and water in their parents' absences. The children had a genetic condition marked by underdeveloped cerebrums, limited cognitive abilities, and a perpetual sense of apathy toward the rest of the world—scientifically named *felis catus*. They all lived very happy lives, though.

EDUCATION:
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This dissertation is dedicated to my father for, among many things, acquainting me with the likes of Carl Sagan, George Carlin, and Kurt Vonnegut, who were among the most pivotal influences in my intellectual development.

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I would like to thank all those who continually pushed me to remain on my chosen path when it was rocky, and kept me from venturing off-road to chase shiny things: my wife Nicolette, my family, my friends; and of course, my mentors and advisors, Stephen J. Ceci, Wendy M. Williams, and Richard A. Depue, who were willing to take in this academically-displaced wanderer. Thanks.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Historically, emotion was regarded quite differently across sub-fields of psychological research. Cognitive psychology was the domain of only what was easily calculable – of language and perception – whilst such intangible things as emotion were considered by most to be irrelevant, or were simply ignored (Davidson, 2000; Miyake & Shah, 1999). In recent years, however, researchers have explored the role of emotion in various cognitive domains in earnest, including working memory, attention, and long-term memory (Banich et al., 2009). The importance of studying emotions was more readily acknowledged by personality and social psychologists many decades ago (e.g., Ekman & Friesen, 1971). Despite emotion's varied history in psychological research, it has become omnipresent in the literature. Today, social and cognitive researchers alike are exploring the role of emotion in human behavior, and oftentimes with respect to topics that cut across traditional social-cognitive boundaries.

A great deal of recent cognitive research has been devoted to understanding the interaction of emotional processes and working memory. The number of studies have accumulated rapidly, as have the inconsistencies across the studies' findings. Many studies of working memory and emotion have examined the effect of affective content on working memory (e.g., Kensinger & Corkin, 2003; Perlstein, Elbert, & Stenger, 2002). However, very few studies have focused on the maintenance of emotions elicited by affective content. Mikels and colleagues (Mikels, Reuter-Lorenz, Beyer, & Fredrickson, 2008) introduced a working memory task requiring the maintenance of emotions. Whereas the maintenance of affective content requires one to maintain a cognitive representation of an affective stimulus, emotion maintenance requires one to maintain his/her own emotions as elicited by affective images. Mikels et al.'s emotion maintenance task required each participant to view an affective image and let their emotions occur naturally, to maintain the intensity of that emotion during a delay interval, and then compare it to the emotional intensity of a second image.

In a selective interference paradigm, Mikels et al. (2008) found that the maintenance of negative emotions is impaired by a secondary emotion regulation task, but unimpaired by a secondary cognitive task. Whereas on a parallel visuospatial maintenance task, performance was impaired by secondary cognitive task, but unimpaired by a secondary emotion regulation task (Mikels et al., 2008). However, other research examining emotional processing with similar dual-task paradigms have found that cognitive load reduces the intensity of emotions (Van Dillen & Koole, 2007). Van Dillen and Koole (2007) had participants view an emotional image then rate their mood after a delay interval, and half of trials included a math task during the delay. They found that participants reported lower intensity moods on math trials relative to trials without a math task (Van Dillen & Koole, 2007). On the surface, these results appear to contradict Mikels et al.'s (2008) findings. However, the underappreciated yet crucial difference between these two lines of research is the fact that Mikels et al.'s (2008) task involved the active maintenance of emotions, while Van Dillen and Koole's (2007) task involved the passive experience of emotions.

In Chapter 1, the tasks of Mikels et al. (2008) and Van Dillen and Koole (2007) are systematically compared to highlight the tasks' differences, and show that both researchers' results are legitimate. Chapter 1 shows the intensity of passively experienced negative emotions is reduced by subsequent cognitive load, the intensity of actively maintained emotions is unaffected by subsequent cognitive load. Additionally, each participant's trait positive and negative affect was assessed in order to control for any trait emotionality differences that could confound the results. The two experimental groups were found to differ significantly in trait positive affect, though it was not problematic for the Chapter 1 analyses. However, the differences did lead to an interesting question, because participants with high trait positive affect also reported more intense negative emotions compared to those with low trait positive affect. Thus, Chapter 1's results suggested the counterintuitive idea that the higher a person's trait positive affect, the more intensely the person experiences negative emotions.

Surprisingly, only one study, an unpublished master's thesis, has specifically examined the relationship of trait affect and the intensity of emotional experiences (Gessner, 2012; Gessner & Filion, 2011). Gessner (2012) used a median-split procedure to compare participants with high and low trait affect, and had them rate the valence and arousal of emotional images. The results showed that those with higher trait positive affect reported negative affective images to be more arousing than those with low trait positive affect (Gessner, 2012). Gessner's (2012) results are consistent with the idea suggested by Chapter 1's results, though further evidence is needed.

In Chapter 2, the relationship between emotional intensity and both state and trait affect was directly investigated. Measures of state and trait affect were obtained independently from two samples of participants. All participants then performed a task in which they rated the intensity of their negative emotions, as elicited by negative affective images. Chapter 2 shows that high state negative affect, or negative mood, is associated with higher intensity negative emotions. Additionally, Chapter 2 shows that high trait positive affect is in fact associated with higher intensity negative emotions. Given the dearth of such research to-date, there are a number of plausible explanations for this findings, as well as questions for future research.

Recent research into the role of emotions in cognitive and social processes has also been directed toward much more applied contexts. In particular, studies have examined the factors influencing the emotion and motivation of women students to pursue careers in science, technology, engineering, and mathematics (STEM). Murphy, Steele, and Gross (2007) found that women STEM students reported a lower sense of belonging and less desire to participate in a STEM conference depicted as having a majority of male attendees, relative to a conference depicted as gender-balanced. In addition, they found that women who watched the predominantly male conference promotion video exhibited faster heart rates and increased skin conductance, relative to women who watched the gender-balanced video (Murphy et al., 2007).

The study in Chapter 3 expanded upon Murphy et al. (2007) by manipulating the depicted environments in additional ways, so as to provide more context to, and be more reflective of, real-world academic environments. Two lab recruitment videos were created, with one depicting a predominantly male lab environment and the other depicting a gender-balanced environment. In addition, the videos' language was manipulated, such that the predominantly male video was described in terms of the traditional, work-focused approach to graduate training, and the gender-balanced video was described in terms of the modern, work-life interaction approach to graduate training. Surprisingly, both women and men STEM students reported a greater sense of belonging and desire to participate in the modern, work-life interaction lab. Consistent with previous research, the results are indicative of a cultural change in ideals and preferences toward work that may have profound consequences for STEM fields in academia.

In this dissertation, I present three studies investigating the role of emotions in social and cognitive functioning. Chapter 1 examines the differential effects of cognitive load on the passive experience, and active maintenance of emotions. Chapter 2 examines the relationship of both state and trait emotionality, to the intensity of emotional experiences. Finally, Chapter 3 examines the socio-emotional factors in

Millenial STEM students' preferences and attitudes toward work. These three studies illustrate the integral role of emotion in social and cognitive functioning, and provide valuable and unique contributions to the respective literatures.

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CHAPTER 1

DIFFERENTIAL EFFECTS OF COGNITIVE LOAD ON EMOTIONAL PROCESSING: EMOTION MAINTENANCE VERSUS PASSIVE EXPERIENCE

Abstract

Two separate lines of research have examined the effects of cognitive load on emotional processing with similar tasks but seemingly contradictory results. Some research has shown that the emotions elicited by passive viewing of emotional images are reduced by subsequent cognitive load. Other research has shown that such emotions are not reduced by cognitive load if the emotions are actively maintained. The present study sought to compare and resolve these two lines of research. Participants either passively viewed negative emotional images or maintained the emotions elicited by the images, and after a delay rated the intensity of the emotion they were feeling. Half of trials included a math task during the delay to induce cognitive load, and the other half did not. Results showed that cognitive load reduced the intensity of negative emotions during passive-viewing of emotional images but not during emotion maintenance. The present study replicates the findings of both lines of research, and shows that the key factor is whether or not emotions are actively maintained. Also, in the context of previous emotion maintenance research, the present results support the theoretical idea of a separable emotion maintenance process.

Introduction

In *The Brothers Karamazov,* Dostoevsky describes Alyosha's thoughts upon returning to his dying elder's bedside:

> *Alyosha firmly and ardently resolved that, despite the promises he had given to see his . . . [family and others] . . . he would not leave the monastery at all the next day, but would stay by his elder until the very end. His heart began burning with love, and he bitterly reproached himself that he had been able, for a moment, there in town, even to forget the one whom he had left . . . [on his death bed] . . . and whom he honored above everyone in the world.* (Dostoevsky, 1990, p. 158)

Though most of us are unable to describe such experiences as elegantly as Dostoevsky, we can likely recall with ease times when we sought distraction from an emotional state, and times when we actively maintained an emotional state amid potential distractions. Two separate lines of research have investigated these everyday phenomena, and despite the distinct similarities between the experimental paradigms, the two have generated opposing conclusions regarding the effects of cognitive load on emotional processing.

Van Dillen and colleagues (Van Dillen, Heslenfeld, & Koole, 2009; Van Dillen & Koole, 2007) have shown that loading working memory reduces the intensity of negative emotional feelings. Their paradigm (Van Dillen et al., 2009; Van Dillen & Koole, 2007) consisted of viewing a negative emotional image, then after a delay interval, rating one's emotional state. Half of task trials included a secondary math task during the delay interval. They found that self-reported negative emotions were lower on trials with a math task, relative to trials without a math task. Furthermore, they found that complex math tasks (two operations) reduced negative emotional feelings significantly more than did simple math tasks (one operation). Hence, the greater the cognitive load, the greater the reduction in emotional intensity (Van Dillen & Koole, 2007; Van Dillen et al., 2009). Neuroimaging research has shown that high cognitive load also reduces activity in brain regions associated with emotional processing (Erk, Kleczar, & Walter, 2007; Kellermann et al., 2012; Van Dillen & Derks, 2012). Additional research has shown that emotion is reduced when working memory is loaded before (Kellermann et al., 2012) or concurrent with (Kron, Schul, Cohen, & Hassin, 2010) an emotional stimulus.

Briefly and passively viewing an emotional image will elicit an emotional feeling. However, that feeling will degrade over time after the stimulus disappears, and will do so more quickly when working memory is subsequently loaded. Van Dillen and Koole (2007) have described this effect as the distraction hypothesis: the idea that loading working memory can distract a person from preexisting negative feelings. In a similar vein, the mere resource hypothesis states that the experience of emotional feelings requires resources – the same limited resources required to perform cognitive tasks (Kron et al., 2010). This idea is consistent with the theoretical ideas of both LeDoux (1996) and Davidson and Irwin (1999): if emotional feelings are conscious, they must have some form of representation in working memory, and thus require resources. It then follows that if emotional feelings are represented in working memory, those representations can be actively maintained amid distractions, similar to representations in verbal or visuospatial working memory.

In contrast to Van Dillen et al., Mikels and colleagues (Mikels, Reuter-Lorenz, Beyer, & Fredrickson, 2008) have found that emotional states can be maintained amid cognitive distraction. Their emotion maintenance task required participants to let their emotions occur naturally while viewing a negative emotional image, and to maintain that emotional intensity across a delay interval. After the delay interval, participants compared the maintained emotion to that of a second image, then selected the image with the higher emotional intensity. On each trial, a participant's response was deemed correct if they selected the image with the higher normative intensity rating of the pair (Mikels et al., 2008). Mikels et al. (2008) administered the emotion maintenance task both in isolation, and with a secondary cognitive task that loaded working memory. The secondary task consisted of articulatory suppression (i.e., counting aloud) during presentation of the first emotional image, and a visual search task during the delay interval. They found task performance was better with concurrent cognitive load than performance without such load (Mikels et al., 2008). Thus, concurrent cognitive load improved participants' ability to maintain an emotion, rather than impairing it.

While the results of the two lines of research may appear to contradict one another – Van Dillen and Koole (2007) showing an impairment of emotional processing by cognitive load, and Mikels et al. (2008) showing no such impairment – they are, in fact, reconcilable when considering their respective task instructions. Whereas Van Dillen et al. (Van Dillen et al., 2009; Van Dillen & Koole, 2007) instructed participants to passively experience the emotion elicited by an emotional image, Mikels et al. (2008) instructed participants to maintain that emotion. The goal of the present study was to show that this difference in task instructions is the reason for the studies' conflicting results.

Present Study

As mentioned, several different experimental paradigms have been used to show that cognitive load can reduce the intensity of emotional feelings. The present study used Van Dillen and Koole's (2007) task paradigm. Given the similarities with Mikels et al.'s (2008) task paradigm, it provides a clear means of comparison. Namely, both tasks begin with the presentation of an emotional image, are followed by cognitive load, and end with a motor response indicative of the effect of the cognitive load on the emotion elicited by the image. To unite the two tasks, Mikels et al.'s (2008) emotion maintenance task was adapted into Van Dillen and Koole's (2007) distraction task. This involved the creation of two experimental conditions. In one condition, participants performed the distraction task in which they passively viewed emotional images (view-only condition). In the second condition, participants performed an emotion maintenance task, that was identical to the view-only task except for additional instructions to maintain the intensity of their emotions on each trial (maintenance condition).

The present hypothesis is that emotional feelings are represented in working memory, and amid competition for resources by other tasks, those representations can be successfully maintained when emotion maintenance is prioritized, but will degrade in intensity otherwise (see also Mikels et al., 2008). Based on this hypothesis, it was predicted that participants instructed to passively view emotional images would report less intense emotions on trials with a math task, relative to trials without a math task. In contrast, it was predicted that participants instructed to maintain the emotional feelings elicited by the images, would report similar emotional intensities on trials with, and trials without, a math task.

Method

Participants

Fifty-two undergraduate students at a large university in the U.S. volunteered to participate in this study, in return for course credit. Data from four participants was incomplete and excluded from the analyses: one participant failed to perform the math task as instructed, two participants experienced computer malfunctions that prevented completion of their experimental session, and one participant chose to discontinue the experiment due to the nature of the emotional images. The 48 participants (33 female, 15 male) included in the analyses had a mean age of 19.4 years[1], SD = 1.08, age_{min} = 18, age_{max} = 22. Forty-six participants were right-handed, and two were left-handed. Participants were randomly assigned to either the emotion maintenance task condition (17 female, 7 male; age M = 19.7, SD = .96, age_{min} = 18, age_{max} = 21) or the view-only task condition (16 female, 8 male; age M = 19.2, SD = 1.17, age_{min} = 18, age_{max} = 22).

Apparatus

The experimental tasks were programmed using E-prime and performed on a desktop PC. All text (white) and images were displayed on a black background. Participants made responses using a standard keyboard: mood rating responses were made with the standard *1-9* keys, and math task responses were made with the *c* and *m* keys, labeled "true" and "false," respectively.

Materials

The experimental task included 54 negative emotional images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Six images were used in practice trials, and 48 images were used in the real trials. No image appeared more than once in a participant's session. The 48 images were split into two groups of 24 images, that were approximately equivalent in terms of the images' normative emotional intensity ratings (Appendix A, Table 1). Normative ratings were obtained in a previous investigation using a large sample (Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005).

Twenty-four math expressions were created: half of the expressions contained one mathematical operation each (i.e., multiplication, division, addition, or subtraction) and the other half contained two mathematical operations each (i.e., multiplication or

[1] One participant in the view-only condition did not report his/her age. Mean age was calculated using data from 47 participants overall, and from 23 participants for the view-only condition.

division, and addition or subtraction). In each expression with two operations, the higher order operation (i.e., multiplication or division) was presented first in parentheses followed by the lower order operation (i.e., addition or subtraction) outside the parentheses (e.g., "(12/3) + 2 = 14"). Twelve math expressions were false including six single-operation and six dual-operation expressions, and the other 12 math expressions were true (Appendix A, Table 2).

Also, this study included pen-and-paper administration of the *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988). Participants indicated the extent they felt each mood state using a 5-point scale: *1* = very slightly or not at all, *2* = a little, *3* = moderately, *4* = quite a bit, *5* = extremely. To assess trait levels of affect, each participant was instructed to indicate the extent he/she feels each mood state in general, that is, on average.

Tasks

The tasks in the emotion maintenance and view-only conditions differed in instruction only. Task trials in both conditions followed the same format, and in each, 50% of trials contained a math problem (*math trials*) and 50% of trials did not contain a math problem (*no math trials*). Both trial types began with a 500-ms auditory tone and fixation-cross, followed by a 5-s presentation of a negative emotional image.

On math trials, a 1-s screen with the word "math" followed the image, denoting the trial was a math trial. Next, a math expression was displayed for 5-s followed by a 2-s screen with a fixation-cross. Participants were required to make a response indicating whether the math expression was "true" or "false." Math task responses made during either the 5-s math problem screen or the subsequent 2-s fixation-cross screen, were recorded. On no math trials, an 8-s screen with fixation-cross followed the emotional image.

Both trial types ended with a response screen containing the question *"How unpleasant do you feel?,"* at which time participants rated the intensity of their emotion at that moment on a scale of *1 = Not at all* to *9 = Very much*. The emotion rating screen remained until a response was recorded, and was followed by a 2.5-s inter-trial interval with fixation-cross (Figure 1.1).

Figure 1.1.

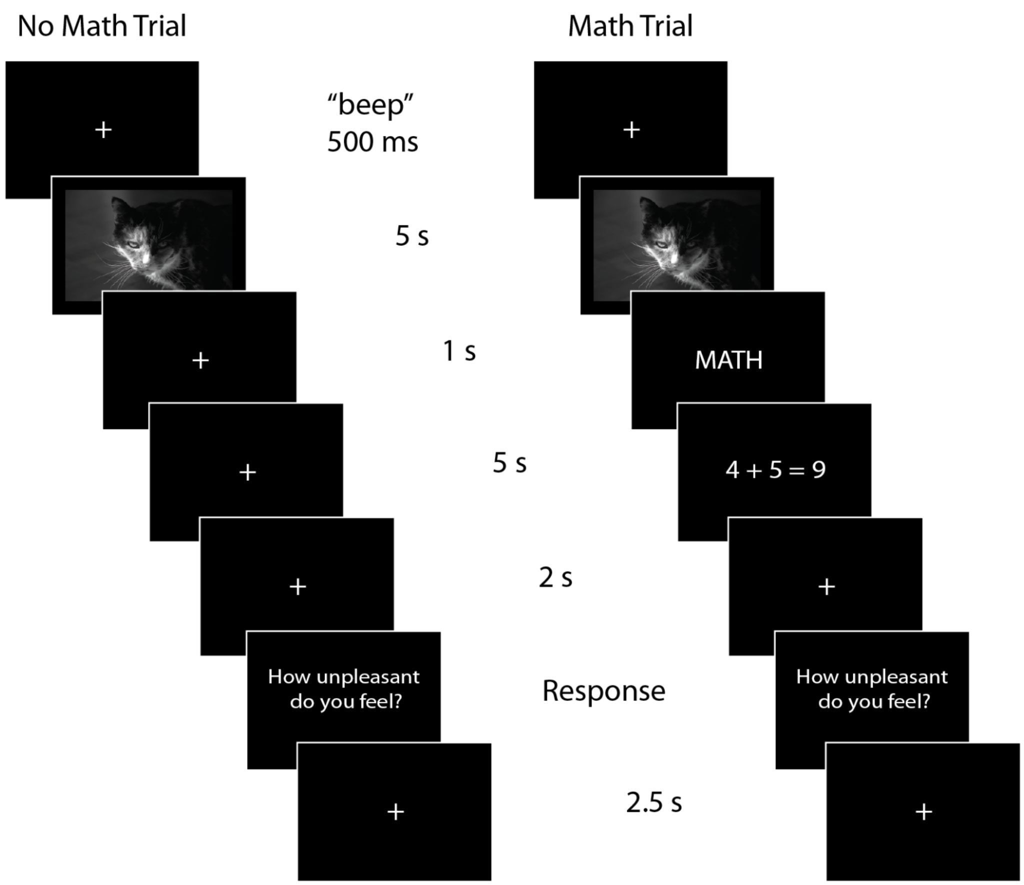

Figure 1.1. Schematic diagram of the two trial types. The trials' formats were the same in both task conditions. The two task conditions differed only in the task instructions: to maintain the emotions elicited by viewing the emotional image (maintenance condition), or to simply view the emotional images (view-only condition). Both trial types began with a 500-ms fixation cross and auditory tone, followed by a 5-s presentation of a negative emotional image. Math trials were denoted by the word *math* appearing on the screen for 1-s following image presentation. On math trials, participants were required to make a response indicating whether the mathematical expression was true or false; responses made during the 5-s presentations of the math expression or the subsequent 2-s fixation cross were recorded. Both trial types ended with a response screen requiring participants to rate their emotion, on a scale from *1* (*Not at all*) to *9* (*Very much*). Emotion rating responses were followed by a 2.5-s intertrial interval.

In both task conditions, participants performed two 24-trial blocks separated by a 25-s rest period. Each block contained 12 math trials and 12 no math trials, presented randomly. The 24 math problems were presented randomly across the two blocks' math trials. To counterbalance the presentation of each image across the two trial blocks and the two trial types, two versions of the experiment were programmed for each task condition. One version designated the Group 1 images to appear on math trials and Group 2 images to appear on no math trials (Appendix A, Table 1). These designations were reversed in the second version. In addition, the 24 images presented in the first trial block of one version, were presented in the second trial block of the second version.

Procedure

The experiment was administered to one participant at a time. Each participant was first shown several sample images, similar to the images appearing in the experiment. Each participant was asked to verify that he or she is comfortable with the nature of the images, and then to provide informed consent in the form of a signature. Next, the experimenter provided a brief overview of the computer tasks. The participants then donned noise-canceling headphones and began the computerized experiment, which included: full instructions for the tasks, six practice trials (three math, three no math), and the two blocks of real trials. Prior to beginning the real trial blocks, each participant was provided the ability to return to previous instruction screens and to perform additional practice trials, if he or she deemed it necessary. Participants were also encouraged to ask the experimenter for clarification on the task instructions (if needed) prior to beginning the real trials.

In both task conditions, the experiment was presented to participants as consisting of three distinct steps per trial. The instructions in the two task conditions differed in terms of the first step only. First, participants were instructed to view the emotional image for the duration of its presentation, and to let their emotions occur naturally. Participants in the emotion maintenance task condition were given the additional instruction to maintain the intensity of the emotion he or she felt from viewing the image, for the duration of each trial. Participants in the view-only condition were given no additional instructions. Second, participants were instructed to make a "true" or "false" response to a math problem indicating whether or not the mathematical expression was true (e.g., the correct response to "(3 * 5) – 4 = 9" would be "false"). On trials without a math problem, participants were instructed to wait for step three. Participants were instructed to make their math responses as quickly and accurately as possible. In addition, participants were instructed to keep their left and right forefingers above the "true" and "false" response keys, respectively, during the real trials to facilitate speeded responses when the math task did appear. Third, participants were instructed to make a response indicating how unpleasant they felt at that moment. Participants were instructed to clear their mind following each emotion rating, in preparation for the next trial. Following completion of the experimental task, participants completed the PANAS.

Data Analysis

Analysis of math task performance was conducted using independent samples *t*-tests (two-tailed) of both reaction time and accuracy to confirm that participants in both task conditions performed commensurately. A positive affect score and a negative affect score was calculated for each participant by summing the respective 10 items of the PANAS, with higher scores representing higher levels of trait affect. Independent samples *t*-tests (two-tailed) were conducted on positive and negative affect scores. A trait affect score was to be included as covariate in the main emotion rating analyses, if the *t*-test indicated the two task conditions were significantly different. This was to account for differences in trait affect that may influence the intensity of emotional experiences. Mean emotion ratings were calculated separately for trials without the math task (no math trials), and for trials including the math task (math trials) in each task condition. Emotion ratings were analyzed in a 2x2 mixed analysis of variance (ANOVA), with trial-type a within-subjects variable (no math, math), task condition a between-subjects variable (maintenance, view-only), and positive or negative affect entered as a covariate (if necessary). A significant interaction of trial-type and task condition was predicted. Given a significant interaction, contrasts were planned to analyze the simple effect of trial-type within each task condition, using paired-samples *t*-tests. It was predicted that the simple effect of trial-type would be significant in the view-only condition (math < no math), but not significant in the maintenance condition.

Results

Math Task

Math task performance was measured in both reaction time (RT) and accuracy (Acc). In both task conditions, participants exhibited high levels of performance: maintenance condition, M_{Acc} = 94.96% (*SD* = 4.25, min = 83, max = 100), and M_{RT} = 2477 ms (*SD* = 531, min = 1708, max = 3523); view-only condition, M_{Acc} = 93.83% (*SD* = 5.97, min = 83, max = 100), M_{RT} = 2325 ms (*SD* = 453, min = 1458, max = 3004). Independent samples *t*-tests indicated that the two task conditions' performances were comparable, as neither accuracies, t (46) = 0.752, p = .456 (two-tailed), 95% confidence interval of the mean difference (CI) [-1.89, 4.14]; nor reaction times, t (46) = 1.071, p = .290 (two-tailed), 95% CI [-134, 439], were significantly different.

PANAS

An independent samples *t*-test comparing the negative affect scores in the view-only condition, M_{NA} = 21.08 (SD = 6.04, min = 13, max = 37), to those in the maintenance condition, M_{NA} = 19.46 (SD = 5.37, min = 11, max = 30), was not significant, t (46) = 0.985, p = .330 (two-tailed), 95% CI [-4.95, 1.70]. However, an independent-samples t-test comparing the two task conditions' positive affect scores revealed that participants' scores in the view-only condition, M_{PA} = 36.4 (SD = 4.75, min = 25, max = 45), were significantly higher than participants' scores in the maintenance condition, M_{PA} = 32.3 (SD = 8.15, min = 17, max = 47), t (46) = 2.14, p = .038 (two-tailed); 95% CI [-8.00, -0.25]. This result remained significant when incorporating a degrees of freedom correction to account for the unequal variances, t (37.02) = 2.14, p = .039 (two-tailed), 95% CI [-8.03, -0.22]. Given this result, positive affect was included as a covariate in the emotion rating task analysis.

Table 1.1.

Adjusted and Unadjusted Means and Standard Deviations of Emotion Ratings by Task Condition and Trial-type

	Unadjusted		Covariate-adjusted	
	No Math	Math	No Math	Math
Task Condition	*M* (SD)	*M* (SD)	*M*	*M*
Maintenance	5.86 (1.52)	5.85 (1.65)	5.98	5.98
View-only	6.14 (1.37)	5.83 (1.48)	6.03	5.70

Note. Participants' emotion ratings indicated how unpleasant they felt at that moment. Ratings were based on a scale of 1 (*Not at all*) to 9 (*Very much*). Means were calculated separately for trials that included a math task (*Math*), and trials without a math task (*No math*). Participants were instructed either to maintain the emotions elicited by the images on each trial (*Maintenance*), or to simply view the images (*View-only*). Task condition was between-subjects, and trial-type was within-subjects. The *covariate-adjusted* means were adjusted for the covariate included in the model, which was evaluated at the following value: PANAS Positive Affect = 34.3542.

Emotion Rating Task

Mean emotion ratings are provided in Table 1.1. A 2x2 mixed ANOVA was run with positive affect entered as a covariate. The analysis did not reveal a main effect of trial-type, F (1, 45) = 1.40, p = .243, power$_{obs}$ = .21, partial η^2 = .030, or a main effect of task condition, F (1, 45) = 0.066, p = .798, power$_{obs}$ = .06, partial η^2 = .001. However, the analysis did reveal a significant interaction of trial-type and task condition, F (1, 45) = 4.71, p = .035, power$_{obs}$ = .57, partial η^2 = .095, d = .601 (Figure 1.2).

Figure 1.2.

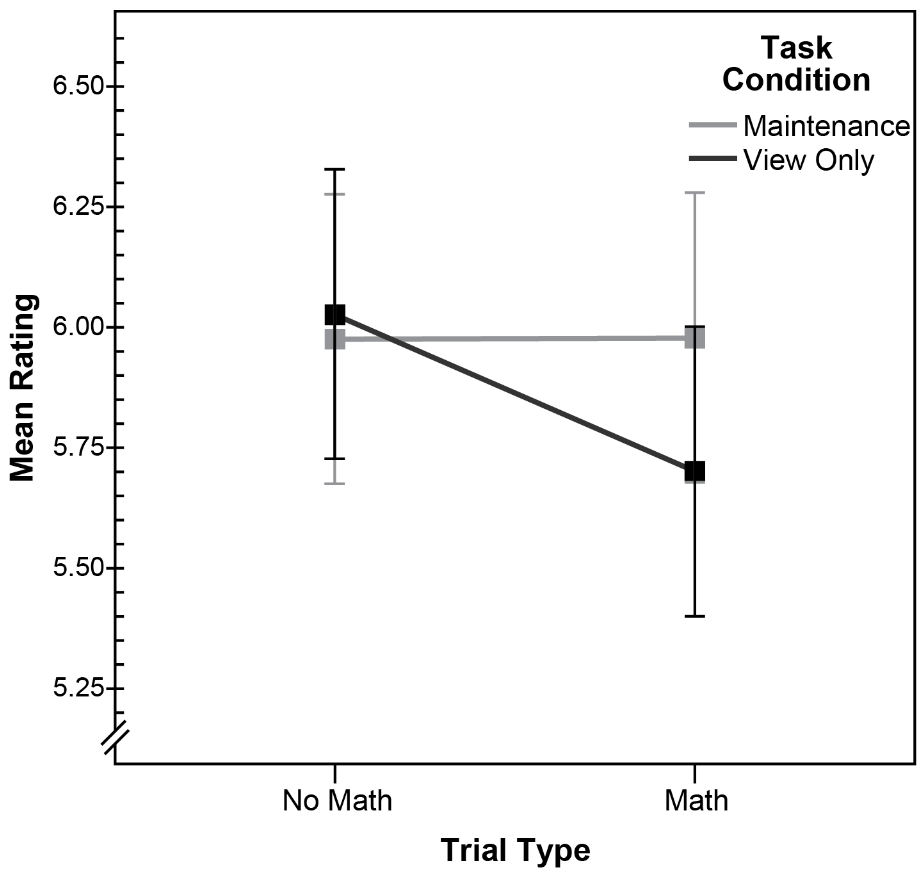

Figure 1.2. Mean emotion ratings by task condition and trial-type. Participants were assigned to one of two task conditions defined by task instructions. Instructions were either to maintain the intensity of the emotion elicited by viewing negative emotional images (*Maintenance*), or to simply view the emotional images (*View Only*). Participants performed both trials that included a math task after the image presentation (*Math*), and trials that did not include a math task (*No Math*). The means displayed were adjusted for the covariate included in the model which was evaluated at the following value: PANAS Positive Affect = 34.3542. Error bars represent standard errors.

To investigate the significant interaction, planned contrasts examined the simple effects of trial-type within each condition. In the maintenance condition, emotion ratings on the math trials, $M = 5.85$, $SD = 1.64$, and emotion ratings on the no math trials, $M = 5.86$, $SD = 1.52$, were not significantly different, t (23) = -0.19, $p = .850$ (two-tailed), 95% CI [-0.18, 0.15], $d = .040$. However, in the view-only condition, emotion ratings on the math trials, $M = 5.83$, $SD = 1.48$, were significantly lower than emotion ratings on the no math trials, $M = 6.14$, $SD = 1.37$; t (23) = -2.62, $p = .008$ (one-tailed), 95% CI [-0.55, -0.06], $d = .546$ (Figure 2.2). The planned contrasts confirm that the significant effects in the ANOVA were driven by the significant simple effect of trial-type in the view-only condition.

Exploratory Analyses

Despite random assignment there were significant differences in trait positive affect between task conditions, which was included as a covariate in the primary analysis. In addition, the two task conditions' math means were more similar than were the no math means. It was reasonably expected that the no math means would be more similar than the math means, given that the former has no cognitive load to interfere with participants' emotions. However, the covariate-adjusted means were in the expected pattern: the task conditions' no math means were more similar than the math means were. Given these results, additional analyses were conducted to explore whether trait positive affect was associated with any additional effects.

An exploratory version of the primary emotion ratings analysis was run to determine if any interactions with positive affect were present. The post-hoc ANOVA included additional interaction terms between the positive affect covariate and the two independent variables (task condition, trial type). This analysis did not reveal any significant effects.

In addition, a series of correlations were run between positive affect and each of the following variables: math trial ratings, no math trial ratings, and the mean rating of the two trial types. These correlations were run for all participants combined, and independently for each task condition. Since the view only condition had both higher positive affect and higher emotion ratings, relative to the maintenance condition, it was predicted that positive affect and emotion ratings would be positively correlated. For all participants combined, positive affect showed significant positive correlations with all three emotion rating variables: no math trial ratings, $r = .268$, $p = .033$; math trial ratings, $r = .256$, $p = .035$; and mean ratings, $r = .266$, $p = .034$ (Table 1.2). The correlations within each task condition were also positive and comparable in magnitude to those of all participants combined, but were not significant (Table 1.2).

Table 1.2.

Correlation of positive affect to math trial, no math trial, and mean ratings, by task condition.

Task Condition	No Math	Math	Mean
All participants	.268*	.256*	.266*
Maintenance	.267	.306	.290
View only	.238	.217	.232

Note. The correlation matrix was truncated to show only the correlations of positive affect to the three emotion ratings. Positive affect was compared with the emotion ratings of each trial-type (no math, math), and the mean rating of the two trial-types. The positive affect correlations were calculated for all participants combined, as well as independently for each task condition (maintenance, view only). *$p < .035$.

Discussion

The present study sought to reconcile the conflicting results of Van Dillen and Koole (2007) and Mikels et al. (2008). It was hypothesized that the effect of cognitive load on emotions is dependent on whether or not those emotions are actively maintained. As predicted, participants instructed to passively-view the emotional images reported less intense emotions on trials with a math task, relative to trials without a math task. In contrast, participants instructed to maintain the emotions elicited by the emotional images, reported similar emotional intensities on both trials with and without a math task. The predictions were supported by a significant interaction of task condition and trial type (d = .601), driven by a significant simple effect of trial type in the view-only condition (d = .546).

The results of the view-only condition replicate those of Van Dillen et al. (Van Dillen et al., 2009; Van Dillen & Koole, 2007), who found a cognitive load-based reduction of emotional intensity. The results of the emotion maintenance condition replicate and extend those of Mikels et al. (2008), who found no detrimental effect of cognitive load on emotion maintenance. While the results of these past studies appeared to contradict one another, the present study's results show that both Van Dillen and Koole's (2007) and Mikels et al.'s (2008) findings are well-founded. It is worth noting that Mikels et al. (2008) found a facilitation of emotion maintenance by the concurrent cognitive task, relative to emotion maintenance in isolation. The facilitation effect was unexpected, and has subsequently lacked adequate explanation and replication (Mikels et al., 2008). As such, a facilitation of emotion maintenance performance was neither predicted nor observed in the present study. Herein, the absence of a cognitive load-based reduction of emotion in the maintenance condition is emphasized, given the abundance of research showing that cognitive load reduces passively experienced emotional feelings (e.g., Erk et al., 2007; Kellermann et al., 2012; Kron et al., 2010; Van Dillen & Derks, 2012; Van Dillen et al., 2009; Van Dillen & Koole, 2007).

The present study provides solid support for the hypothesis that the two studies' opposing results are due to the difference in task instructions (cf. Mikels et al., 2008; Van Dillen & Koole, 2007). This study was designed to compare the two tasks (emotion maintenance, view-only) as closely as possible. Participants in both conditions were presented with the same stimuli and math problems in identical trial formats (e.g., timing, stimulus duration, trial length, etc.). The sole methodological difference between the two conditions was the additional pre-task instruction in the maintenance condition to maintain emotions. All other instructions were identical in the two conditions.

Limitations

A noteworthy and unexpected finding in the present study's results was the higher no-math trial emotion ratings in the view-only condition, relative to that in the maintenance condition, and the similarity of the math trial emotion ratings in the two task conditions. Though not specifically predicted, the a priori expectation was for the opposite pattern to be observed: similar no-math trial emotion ratings in the two task conditions, and lower math trial emotion ratings in the view-only condition, relative to the maintenance condition. Similar no-math trial emotion ratings were expected because a passively-experienced emotional feeling is not likely to degrade much in the relatively short 8 s interval between stimulus offset and rating one's emotion, when no secondary task or stimulus is presented. Thus, it was reasonable to expect that the ratings of a passively-experienced emotions and maintained emotions would be more comparable on no-math trials than on math trials.

There are two possible explanations for this unexpected finding, given the current set of data. One possibility is that differences in trait positive affect influence the intensity of negative emotions. Despite random assignment in the present study, there were significant differences in trait positive affect between the two task conditions. Specifically, the view-only condition participants reported significantly higher levels of trait positive affect, relative to the maintenance condition participants. This suggests that higher levels of trait positive affect are associated with more intense negative emotional experiences. Overall, research to support this explanation is lacking in the literature. However, one study did find that people with high trait positive affect rated negative emotional images higher in arousal, than did people with low trait positive affect (Gessner, 2012; see also Gessner & Filion, 2011).

A second possibility is that emotions experienced passively are more intense than emotions that are actively and effortfully maintained. It is possible the mechanisms responsible for maintaining emotions somehow modify the intensity of those emotions. There are only a few studies on emotion maintenance, and the present study is the first to compare maintained emotions to passively experienced emotions. However, research on affect labeling may shed some light on this possibility. Several studies have shown that the act of labeling emotional experiences, reduces affect-related amygdala activity, relative to passive emotional experiences (e.g., Berkman & Lieberman, 2009; Burklund, Creswell, Irwin, & Lieberman, 2014). Similarly, affect labeling, relative to passive experiencing, has been associated with lower self-reported emotional intensity (Lieberman, Inagaki, Tabibnia, & Crockett, 2011). It may be that maintenance condition participants were inadvertently labeling their emotions, though instructions asked them to simply maintain the emotional intensity they were experiencing. Alternatively, the two may share an underlying attentional mechanism that plays a role in intensity reduction, since both emotion maintenance and affect labeling involve attending to the emotion.

Further research would be needed to make a definitive case for either possibility. For several reasons, the present data are more suggestive of the first possibility: that trait positive affect is positively associated with negative emotional intensity. First, the two conditions' *covariate-adjusted* no math trial means were more similar than the math trial means, which was the expected pattern. Second, the exploratory analyses revealed significant positive correlations between trait positive affect and emotion ratings for all participants combined. This included significant correlations of trait positive affect with no math trial ratings, math trial ratings, and overall ratings. Third, a main effect of condition that would provide support for the second possibility, was not significant.

Theoretical Implications

The present study provides further support for the mere resource hypothesis (Kron et al., 2010) which states the experience of emotion requires use of the limited resources of working memory (see also, Davidson & Irwin, 1999; LeDoux, 1996). This is evident in the view-only task condition's results showing a cognitive load-based reduction in emotional intensity. The view-only condition's results also replicate Van Dillen and Koole's (2007) findings, and support their distraction hypothesis which states cognitive load can distract a person from pre-existing negative feelings. As described in the introduction, these (and related) hypotheses have received considerable discussion, and experimental support in the extant literature (Erk et al., 2007; Kellerman et al., 2012; Kron et al., 2010; Van Dillen & Derks, 2012; Van Dillen et al., 2009; Van Dillen & Koole, 2007). The present study's findings are a more valuable contribution to the emotion maintenance literature. The present study's simplicity limits the conclusions that can be made. But in the context of previous emotion maintenance research, the present results do provide some valuable insight.

The concept of a working memory mechanism for maintaining emotions was originally put forth by LeDoux (1996) and Davidson and Irwin (1999), and received experimental support from Mikels et al. (2008). Mikels et al. (2008) found a double-dissociation of emotion maintenance and visuospatial maintenance: emotion maintenance was selectively impaired by a secondary emotion regulation task, and visuospatial maintenance was selectively impaired by a secondary cognitive task. The present study's results are consistent with the hypothesis of a separable working memory mechanism responsible for maintaining emotions (Mikels et al., 2008). To be clear, the present study was not designed to dissociate an emotion maintenance mechanism from verbal and visuospatial maintenance mechanisms. However, finding that cognitive load has no effect on emotion maintenance is the result expected in the presence of a domain-specific emotion maintenance process. When the present study is considered along with Mikels et al. (2008), it provides further support for a separable emotion maintenance mechanism.

Mikels et al. (2008) was designed to show that emotion maintenance does not rely on either verbal or visuospatial working memory maintenance resources. Their cognitive secondary task taxed both sets of resources without impairing emotion maintenance. The present study adds support for the emotion maintenance concept by showing that it is also unimpaired by a secondary math task. Mental arithmetic is known to engage executive working memory for carrying out mathematical operations, and verbal working memory for keeping a running tally of the operations' results (Baddeley, 1966; Logie, Gilhooly, & Wynn, 1994). The math task in the present study, however, is predominantly an executive working memory task, given the limited need for maintaining a running tally (i.e., maximum of two operations). Thus, in itself, the present study provides evidence against a valid counterargument to Mikels et al. (2008):

that emotion maintenance may be governed by the central executive, rather than a separable maintenance mechanism. While Mikels et al.'s (2008) secondary cognitive task was both verbal and visuospatial, the secondary emotion regulation task did require executive resources (Ochsner, Bunge, Gross, & Gabrieli, 2002; Ochsner & Gross, 2008). Thus, the emotion regulation task's impairment of emotion maintenance in Mikels et al. (2008) could just as easily be attributed to an impairment of executive processing, as to an impairment of emotional processing.

The present study's math task was central executive-based, but non-emotional. If the central executive were also responsible for emotion maintenance, then the absence of an emotion maintenance impairment by the math task, should coincide with an impairment of math task performance by emotion maintenance. However, the present results showed that participants in both task conditions performed the math task equally well. It would appear the math task and emotion maintenance do not rely on the same processes. The math task's reliance on executive processes is well-established, so the present results are evidence against an executive-based emotion maintenance process. This line of reasoning is similar to that of Hitch and Baddeley (1976), when they found both a verbal reasoning task (executive) and a verbal maintenance task (verbal) could be performed successfully at the same time. Such evidence helped to establish the separability of executive, and verbal maintenance, resources in the multi-component model of working memory (Baddeley, 1986; Baddeley & Hitch, 1974).

However, it could be argued that the central executive may play some role in emotion maintenance since emotions were unaffected by the math task only when participants were *instructed* to maintain those emotions. Thus, it is possible that emotion maintenance may not be automatic, as has been shown with some forms of verbal and visuospatial maintenance (Crowder & Morton, 1969; Salame & Baddeley, 1982; Saults &

Cowan, 2007; Thorn & Gathercole, 2001). Research showing that cognitive load disrupts emotional processing whether the load is introduced before (Kellermann et al., 2012), during (Kron et al., 2010), or after (Van Dillen & Koole, 2007) the emotional stimulus, is also consistent with the idea that maintenance is not automatic. Again, however, the task conditions' equivalent math task performances is evidence against the idea that the central executive maintains emotions. The central executive's role in emotion maintenance (if any) would seem to be simply the initiation, or activation, of the emotion maintenance mechanism which, once activated, can successfully maintain emotions with little subsequent demand from the executive.

Future Directions

The present study was a simple and successful attempt to reconcile two lines of research, which previously appeared to have conflicting results. Though, as discussed in the theoretical implications, the present study does also raise some interesting ideas surrounding the nature of an emotion maintenance mechanism, and its place in theories of working memory. While the argument has been made herein that the maintenance of emotions does not rely primarily on executive, verbal, or visuospatial working memory resources – it is far from conclusive. The present study provides some support, though the only direct attempt to dissociate emotion maintenance to date is Mikels et al. (2008). Future investigations into the separability of an emotion maintenance mechanism, and the precise role of the central executive in emotion maintenance should prove fruitful. In addition, the present study's unexpected finding of a between-groups difference in no-math trial emotion ratings lacks an adequate explanation. Future research investigating the relationship of trait positive affect and the intensity of negative emotional experiences would be particularly illuminating. As would research into the possible moderating effect of emotion maintenance on emotional intensity.

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CHAPTER 2

THE INFLUENCE OF STATE AND TRAIT AFFECT ON THE INTENSITY OF NEGATIVE EMOTIONS

Abstract

An abundance of research has been dedicated to examining trait affect, yet little has investigated the relationship of trait affect and the intensity of discrete emotional experience. The results of Chapter 1 suggested that those with high trait positive affect may experience higher intensity negative emotions, relative to those with low trait positive affect. The present study sought to test this idea with additional data from two samples of participants. Participants completed the positive and negative affect schedule (PANAS): Sample 1 participants completed the state version, and Sample 2 participants completed the trait version. Following the PANAS, each participant performed a task requiring him/her to view a series of negative emotional images, and to rate the intensity of the emotions he/she felt from viewing each image. Results showed that both state negative affect (Sample 1) and trait positive affect (Sample 2) correlated positively with image intensity ratings. The state negative affect finding is consistent with past research on mood congruence. The trait positive affect finding backs up the results of Chapter 1, though a full understanding of this relationship will require further research, given the limitations of the present study. Those limitations, as well as possible explanations, are discussed.

Introduction

Arguably, two of the most prominent motivations propagating human evolution are the motivation to continue living, and the motivation to live happily. In the psychological literature, the concept of happiness is a significant component of several concepts, such as well-being and positive affect (Howell, Kern, & Lyubomirsky, 2007). The concept of positive affect, in addition to happiness, includes emotions such as excitement and joy (Cohen & Pressman, 2006; Watson, Clark, & Tellegen, 1988). Positive and negative affect are typically measured using one of several different psychological self-report inventories (e.g., Affect balance scale, Bradburn, 1969; Behavioral inhibition and activation systems [BIS/BAS], Carver & White, 1994; State-trait emotion measure, Levine et al., 2011; Positive and negative affect schedule [PANAS], Watson et al., 1988). It can also be measured with respect to different periods of time, so as to inform researchers how much positive affect a person is experiencing currently, over the last month, or on average. The two most common measurements are state affect and trait affect (Clark, Watson, & Leeka, 1989; Watson, et al., 1988), which are considered to occupy opposite ends of a time continuum (Watson, 2000). Whereas state affect describes a person's mood in-the-moment and can vary widely within and between days, trait affect describes a person's affect on average and is stable over long periods of time (Clark et al., 1989; Watson, 2000; Watson & Walker, 1996).

Affect, Moods, and Emotions

The terms affect, mood, and emotion are oftentimes conflated in the literature (Silvia & Warburton, 2006). Given the importance of the terms' specificity herein, it is important to define these terms (for similar distinctions, see Kron, Schul, Cohen, & Hassin, 2010; Silvia & Warburton, 2006; Watson, 2000). The general term affect (or affective) broadly encompasses aspects of emotions and moods, and can also be used as an adjective to denote the quality of being able to elicit emotions or moods (e.g., an affective stimulus). Emotion is defined herein as a brief (order of seconds to minutes), arousing, and discrete affective experience for which the cause or eliciting stimulus is known (Silvia & Warburton, 2006). Mood (or state affect) is defined as a sustained (order of minutes to hours), mild, and nebulous affective experience that is positive or negative, and lacks a well-defined cause (Silvia & Warburton, 2006). Trait affect is defined as a stable individual difference reflecting a person's relative disposition toward positive and negative emotions and moods over extended periods of time (Watson, 2000).

Positively Beneficial

Trait positive affect is has favorable associations with a wide range of health and life outcomes. Studies have consistently shown that people high in trait positive affect experience better short- and long-term health outcomes than people low in trait positive affect (Howell et al., 2007). Much of the evidence has come from correlational studies, though the quasi-experimental and experimental studies have largely corroborated the correlational findings (Dockray & Steptoe, 2010; Salovey, Rothman, Detweiler, & Steward, 2000). High trait positive affect has been associated with lower levels of stress-related inflammation (Prather, Marsland, Muldoon, & Manuck, 2007; Steptoe, O'Donnell, Badrick, Kumari, & Marmot, 2008), lower mortality (Chida & Steptoe, 2008), fewer symptoms of pain (Cohen & Pressman, 2006), better antibody responses to vaccinations (Marsland, Cohen, Rabin, & Manuck, 2006), better recovery from academic stress (Papousek et al., 2010), and better cardiovascular health (Boehm & Kubzansky, 2012). Longitudinal studies have found high positive affect is associated with lower risk for developing coronary heart disease (Kubzansky, & Thurston, 2007) and lower rates of stroke (Ostir, Markides, Peek, & Goodwin, 2001), while controlling for other known risk factors. In the long-term, those with high trait positive affect have better overall health, live longer lives (Chida & Steptoe, 2008; Diener & Chan, 2011; Pressman & Cohen, 2005), and are more successful (Lyubomirsky, King, & Diener, 2005). Trait positive affect is also shown to have favorable consequences for social relationships. Specifically, people with high trait positive affect experience higher quality romantic relationships and are more likely to be in a relationship, compared to those with low trait positive affect (Berry & Willingham, 1997).

Trait Affect and Emotional Intensity

Given the multitude of benefits associated with trait positive affect, the intuitive notion would be that higher trait positive affect is associated with lower intensity negative emotions, relative to people low in trait positive affect. This would be consistent with research showing a buffering effect of trait positive affect on the development of depression symptoms (Riskind, Kleiman, & Schafer, 2013). However, the results of Chapter 1 suggested that trait positive affect may be positively associated with the intensity of negative emotions. In other words, the higher a person's trait positive affect, the more intense their negative emotions are in response to a given stimulus. Positive and negative affect are orthogonal constructs, and low positive affect does not necessarily entail high negative affect (Watson et al., 1988; Watson & Tellegen, 1985). Furthermore, trait affect is a measure of how frequently a person experiences positive and negative affect over long periods of time, but provides no information as to the intensity of his/her discrete emotional experiences. Knowing the trait positive affect of two people can inform you which person experiences positive affect more frequently, but tells you nothing about how the two compare in the intensity of their discrete emotional experiences.

Surprisingly, research exploring the relationship of trait affect to discrete emotional experiences is lacking. To my knowledge, only one study has directly investigated the relationship of trait affect to emotional experiences: an unpublished master's thesis (Gessner, 2012; Gessner & Filion, 2011) with results consistent with those of Chapter 1 herein. Using a median-split to create high and low trait affect groups, Gessner (2012) found that negative emotional images were rated higher in arousal by the high positive affect group, relative to the low positive affect group. However, given that it is unpublished, the study can only be afforded so much weight.

There are other studies that, while not direct investigations of trait affect and emotions, can nonetheless provide some insight. Truong and Yang (2014) compared older and younger adults on a working memory task that included emotional distracters. Older adults reported significantly higher trait positive affect, and experienced significantly greater interference from negative emotional distracters, relative to younger adults (Truong & Yang, 2014). The direct statistical relationship of trait positive affect, and emotional distraction on the working memory task were not reported, so the strength of the relationship is unknown. However, it could suggest that those with higher trait positive affect experienced more intense negative emotions in response to the distracters, which in turn resulted in greater interference on the working memory task.

In the literature on affective style, several studies have indicated a relationship between frontal lobe asymmetry, trait affect, and emotional intensity (Davidson, 2003). Using resting state EEG, researchers have shown that relatively higher left hemisphere activity is associated with higher trait positive affect, and relatively higher right hemisphere activity is associated with higher trait negative affect (Davidson 1998, 2003; Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997; Tomarken, Davidson, Wheeler,

& Doss, 1992). This frontal asymmetry has been associated with trait affect measured by the PANAS (Tomarken et al., 1992) and the BIS/BAS (Sutton & Davidson, 1997). Wheeler, Davidson, and Tomarken (1993) found that frontal brain asymmetry at rest is also associated with the intensity of emotions in response to film clips. Those with relatively higher left frontal activation reported more intense emotions to positive film clips, and those with relatively higher right frontal activation reported more intense emotions to negative film clips (Wheeler et al., 1993). However, Wheeler et al. (1993) did not report a measure of trait affect, so the connection between the intensity of emotions and trait affect is indirect, at best.

Notably, an attempt to replicate Wheeler et al. (1993) failed (Hagemann, Waldstein, & Thayer, 2003), and the frontal asymmetry and trait affect associations have not held across all studies (Davidson, 2003; Hagemann, Naumann, Becker, Maier, & Bartussek, 1998; Hagemann et al., 1999). Hagemann et al. (1999) found an association between relatively higher left hemisphere activity and trait negative (rather than positive) affect, and no association between asymmetry and trait positive affect. In another study, Hagemann et al. (1998) found that those with relatively higher frontotemporal activation at rest reported more intense emotions to negative images, whereas those with relatively higher right frontotemporal activation at rest reported more intense emotions to positive images. Hofmann (2007) has shown that these relationships of state and trait affect to brain activity are complex, and that both trait and state affect have an effect on activity.

Unfortunately, research on the association of trait affect and the intensity of emotional experiences is lacking. Some studies do suggest that high trait positive affect is associated with higher intensity negative emotions (Truong & Yang, 2014). The research on affective style has come close to addressing this topic, but overall has been inconsistent (Hagemann et al., 1998), and focused more on trait affect's association with brain activity, than its association with emotional intensity. On the other hand, the association between state affect and emotional experiences has received more attention from researchers, and the findings are much clearer.

State Affect and Emotional Intensity

Research exploring the effects of moods on various aspects of behavior and cognition is abundant (Blanchette & Richards, 2010). In particular, research on the effects of mood on various tasks with affective stimuli dates back more than three decades (Blaney, 1986; Ellis & Ashbrook, 1989; Gendolla, 2000; Matt, Vazquez, & Campbell, 1992). Much of this research has pertained to mood-congruency effects: the facilitative effect of mood on the processing of valence-congruent emotions or affective stimuli (Blanchette & Richards, 2010). For example, a field study by Forgas (1998) found a mood congruent bias in perceptions of, and responses to, a confederate's request. Students in a library were exposed to positive or negative images to induce mood, and were then approached by a confederate who made either a polite or impolite request. Forgas (1998) found that participants in a negative mood had more unfavorable perceptions of the confederate's request, particularly for unusual or impolite requests, relative to participants in a positive mood (Forgas, 1998).

Several studies have shown a mood-congruent bias in the processing of emotional facial expressions, in both clinical and healthy samples. Compared to controls, currently depressed bipolar patients have shown more sensitivity to recognizing negative emotional expressions, and less sensitivity to recognizing positive emotional expressions (Gray et al., 2006). Schmid and Mast (2010) induced participants into a positive or negative mood, and tested their ability to recognize emotional expressions. Those in the positive mood condition were more accurate in recognizing positive expressions and less accurate in recognizing negative expressions, and vice versa for those in the negative mood condition (Schmid & Mast, 2010). Similarly, Bouhuys, Bloem, and Groothuis (1995) found that an induced negative mood led to a negative bias in the perception of both negative and emotionally-ambiguous schematic facial expressions. Another study (Niedenthal, Halberstadt, Margolin, & Innes-Ker, 2000) had participants view animated faces that progressed from full emotional expressions to neutral expressions, and asked them to indicate the point at which the emotional expression was no longer evident. Niedenthal et al. (2000) found that participants' response times were longer when judging emotional expressions congruent with their mood, and shorter when judging incongruent emotional expressions. In other words, participants perceived mood-congruent expressions to be evident in faces closer to a fully neutral expression, than they perceived mood-incongruent expressions to be (Niedenthal et al., 2000).

Niedenthal and others have shown mood-congruency effects for several verbal tasks as well. Niedenthal and Setterlund (1994) induced participants into a happy or sad mood, and had them perform a lexical task in which they responded whether a letter string was a word or non-word. Mood congruence effects were shown in both conditions, as those in a happy mood were faster to respond to happiness-related words, and those in a sad mood were faster to respond to sadness-related words (Niedenthal & Setterlund, 1994). A subsequent study (Niedenthal, Halberstadt, & Setterlund, 1997) replicated and extended these results by finding a mood-congruence effect on a word-naming task that required the pronunciation of a series of words. Those in the happy condition were faster to pronounce words congruent with happiness, and those in the sad condition were faster to pronounce words congruent with sadness (Niedenthal et al., 1997).

Overall, mood congruent effects have been found on a wide range of tasks involving memory, judgment, and free association; in the context of both natural and experimentally-induced moods (e.g., Mayer, Gaschke, Braverman, & Evans, 1992; Rusting, 1999). However, most relevant to the present study is the effect of mood on emotional intensity. A study (Dolcos et al., 2013) investigating the effect of emotional distracters on working memory performance found that negative mood was negatively correlated with performance of a working memory task with negative distracters. The results suggest a mood congruent effect: that higher negative mood enhanced the emotions elicited by the negative distracters, and led to a greater performance impairment (Dolcos et al., 2013).

Additionally, a series of experiments by Neumann, Seibt, and Strack (2001) found mood-congruent effects on the intensity of emotions. One experiment had participants induced into a positive or negative mood and perform an achievement test, after which they received either above or below average feedback (irrespective of their actual performance). Neumann et al. (2001) found that positive mood participants who received above average feedback reported significantly higher positive emotions (i.e., pride), relative to all other participants. Similarly, in a second experiment, positive mood participants reported higher intensity emotions (i.e., amusement) in response to a comic strip, relative to negative and neutral mood participants (Neumann et al., 2001). A final experiment using an alternate mood induction technique replicated the second's results, showing via EMG recordings that positive mood participants smiled more (Neumann et al., 2001).

Present Study

The goal of the present study was to illuminate the questions raised by Chapter 1's results. Specifically, Chapter 1's results suggested that trait positive affect is positively correlated with the intensity of negative emotions. The present study addressed this by assessing the relationship of both state and trait affect to the intensity of emotions. Two samples performed a task in which they viewed negative emotional images, and rated the intensity of the emotions they felt in response. Prior to the task, either state or trait affect was assessed (Samples 1 and 2, respectively). Based on the mood-congruence literature, it was hypothesized that state negative affect enhances the intensity of negative emotions. Based on the results of Chapter 1, it was hypothesized that trait positive affect is associated with an enhancement of the intensity of negative emotions. It was predicted that Sample 1 would reveal a positive correlation between state negative (but not positive) affect and participants' emotional intensity ratings. Also, it was predicted that Sample 2 would reveal a positive correlation between trait positive (but not negative) affect and participants' emotional intensity ratings.

Method

Participants

Sample 1 comprised 55 undergraduate students at a large U.S. university who volunteered to participate in return for course credit. During data analysis, it was found that one participant entered the maximum emotion rating for every image in the experiment. Data from this participant was excluded from the analyses. The remaining 54 participants (39 female, 15 male) had a mean age of 19.4 years, SD = 1.55, $age_{min} = 17$, $age_{max} = 27$. Fifty-two participants were right-hand dominant, and two were left-hand dominant.

Sample 2 comprised 50 undergraduate students at a large U.S. university who volunteered to participate in return for course credit. These 50 participants were originally recruited for the study in Chapter 1 of this dissertation. Data from one participant was incomplete because he/she chose to discontinue the experiment due to the emotional nature of the images. Data from this participant was excluded from the analyses. The remaining 49 participants (34 female, 15 male) had a mean age of 19.4 years[1], SD = 1.09, age_{min} = 18, age_{max} = 22. Forty-seven participants were right-hand dominant, and two were left-hand dominant.

Apparatus

The experimental task was programmed using E-prime and performed on a desktop PC. All text (white) and images were displayed on a black background. Participants made responses using the *1-9* keys along the top of a standard keyboard.

Materials

This study included a pen-and-paper administration of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988). Participants indicated the extent they felt each mood state using a 5-point scale: *1* = "very slightly or not at all," *2* = "a little," *3* = "moderately," *4* = "quite a bit," *5* = "extremely." Sample 1 participants were instructed to indicate the extent to which they were currently feeling each mood state. Sample 2 participants were instructed to indicate the extent they feel each mood state in general, that is, on average. Thus, Sample 1 provided an assessment of state affect, and Sample 2 provided an assessment of trait affect.

The experimental task included 51 negative emotional images from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Three images were used in practice trials, and 48 images were used in the real trials. None of the 48 images appeared more than once in a participant's session. However, all

[1] One participant did not report his/her age. Age statistics were calculated using data from 48 participants.

participants had previously viewed this set of images while participating in a previous study[2].

Intensity Rating Task

The emotion intensity rating task required participants to view negative emotional images, and rate the images' emotional intensity. Each trial began with a 500-ms auditory tone and fixation cross, followed by a 5-s presentation of a negative emotional image, and ended with an emotion rating response screen. A 2.5-s inter-trial interval with a fixation cross followed each response. Participants were instructed to view each image for its duration, and to let their emotions occur naturally. At the response screen, participants were asked to rate the intensity of the emotion they felt while viewing the image. Emotional intensity was rated on a scale of *1* ("lowest intensity") to *9* ("highest intensity"). Participants were also asked to relax and clear their minds between trials. Each participant performed two 24-trial blocks, with a 20-s rest period between blocks.

Procedure

The experiment was administered to one participant at a time. Each participant was first provided with a consent form and a sheet containing several sample images, similar to the images appearing in the experiment. Each participant was asked to verify that he or she is comfortable with the nature of the images, and then to provide informed consent in the form of a signature. Each participant was then administered the PANAS: Sample 1 completed the state version, and Sample 2 completed the trait version. Next, the experimenter provided a brief overview of the emotion rating task. Participants then donned noise-canceling headphones, and began the computerized task which included: full instructions for the emotion rating task, three practice trials,

[2] For Sample 2, the previous study is reported in Chapter 1 of this dissertation.

and the two blocks of real trials. The instructions and practice trials were self-paced, and each participant was provided the option of returning to previous instructions screens or completing additional practice trials, if he or she deemed it necessary. Participants were also encouraged to ask the experimenter for clarification on the task instructions (if needed) prior to beginning the real trials.

Results

Intensity Ratings

Table 2.1 provides the means and standard deviations of both samples' image intensity ratings. An independent samples t-test comparing the mean image intensity ratings of Sample 1, $M = 6.13$ (SD = 1.58), and Sample 2, $M = 6.04$ (SD = 1.28), was not significant, $t\ (101) = 0.337$, $p = .737$ (two-tailed), indicating the two samples rated the images' intensities equivalently.

Comparison to Chapter 1

Participants in the present Sample 2 also provided data for Chapter 1 of this dissertation. Trait affect scores for these participants relied on the same data in both chapters. In Chapter 1, the results suggested a positive association between trait positive affect, and mood ratings on the emotion rating task, providing the basis for the present study. Though the experimental tasks in the two studies were quite different, the same 48 images were used to elicit moods in Chapter 1, and to obtain image intensity ratings in the present study. Thus, it was prudent to assess the association of the mood ratings (math, no math) in Chapter 1, and the present study's image intensity ratings. Correlations were run between the three sets of ratings: math trial ratings and no-math trial ratings, $r = .944$; image intensity ratings and no-math trials, $r = .827$; image intensity ratings and math trials, $r = .822$ (all ps < .001). The two image intensity ratings correlations were each compared to the correlation of Chapter 1's math and no-math trial mood ratings. To do so, Williams' (1959) *t*-test for comparing two non-independent correlations that have one variable in common (see also Steiger, 1980)[3]. The correlation of image intensity rating and no-math trials, was not significantly different, t (45) = 0.18, p = .856, from the correlation of image intensity rating and math trials. However, the correlation of image intensity rating and no-math trials, was significantly different from the correlation of math and no-math trials, t (45) = 4.01, p = .0002. Also, the correlation of image intensity rating and math trials was significantly different from the correlation of math and no-math trials, t (45) = 4.20, p = .0001. The significant differences between the Chapter 1 mood ratings and the present image intensity ratings, are indicative of the two studies' different experimental tasks.

Table 2.1.

Means and Correlations of PANAS Scores and Image Intensity Ratings

Measure	1	2	3	*M*	SD
1. Positive affect	–	-.105	.290*	34.24	6.89
2. Negative affect	.085	–	-.130	20.47	5.82
3. Image intensity rating	.138	.258*	–	6.04	1.28
M	26.37	13.48	6.13		
SD	6.29	3.68	1.58		

Note. Pearson correlations for Sample 1 (n = 54) are presented below the diagonal, and those for Sample 2 (n = 49) are presented above the diagonal. Likewise, means and standard deviations for Sample 1 are presented in rows below the diagonal, and those for Sample 2 are presented in columns above the diagonal. Positive and negative affect was scored by summing the respective 10 items of the PANAS for each participant. Sample 1 data represents state-level affect, and Sample 2 data represents trait-level affect. Image intensity ratings were based on a scale of *1* (lowest intensity) to *9* (highest intensity). Participants in both samples were asked to rate the same 48 negative emotional images. *p < .03.

[3] See Limitations sub-section of the Discussion section for additional explanation of the use of this statistical procedure.

PANAS

For each sample, positive and negative affect scores were tallied for each participant by summing the ratings on the respective 10 items of the PANAS. For Sample 1, state positive affect $M = 26.37$, SD = 6.29, min = 13, max = 39, and state negative affect $M = 13.48$, SD = 3.68, min = 10, max = 22 (Table 2.1). For Sample 2, trait positive affect $M = 34.24$, SD = 6.89, min = 17, max = 47, and trait negative affect $M = 20.47$, SD = 5.82, min = 11, max = 37 (Table 2.1).

Correlations

Pearson correlations were run to assess the relationship of positive and negative state and trait affect, and image intensity ratings (Table 2.1). All *p*-values for correlations were two-tailed, except those for which a specific relationship was predicted (one-tailed tests are denoted as such). In Sample 1 (n = 54), the correlation of state positive affect and state negative affect, $r = .085$, $p = .541$, and the correlation of state positive affect and image intensity rating, $r = .138$, $p = .318$, were not significant. As predicted, there was a significant positive correlation between state negative affect and image intensity rating, $r = .258$, $p = .030$, one-tailed (Figure 2.1). In Sample 2 (n = 49), the correlation of trait positive affect and trait negative affect, $r = -.105$, $p = .474$, and the correlation of trait negative affect and image intensity rating, $r = -.130$, $p = .374$, were not significant. As predicted, there was a significant positive correlation between trait positive affect and image intensity rating, $r = .290$, $p = .022$, one-tailed (Figure 2.1).

Figure 2.1.

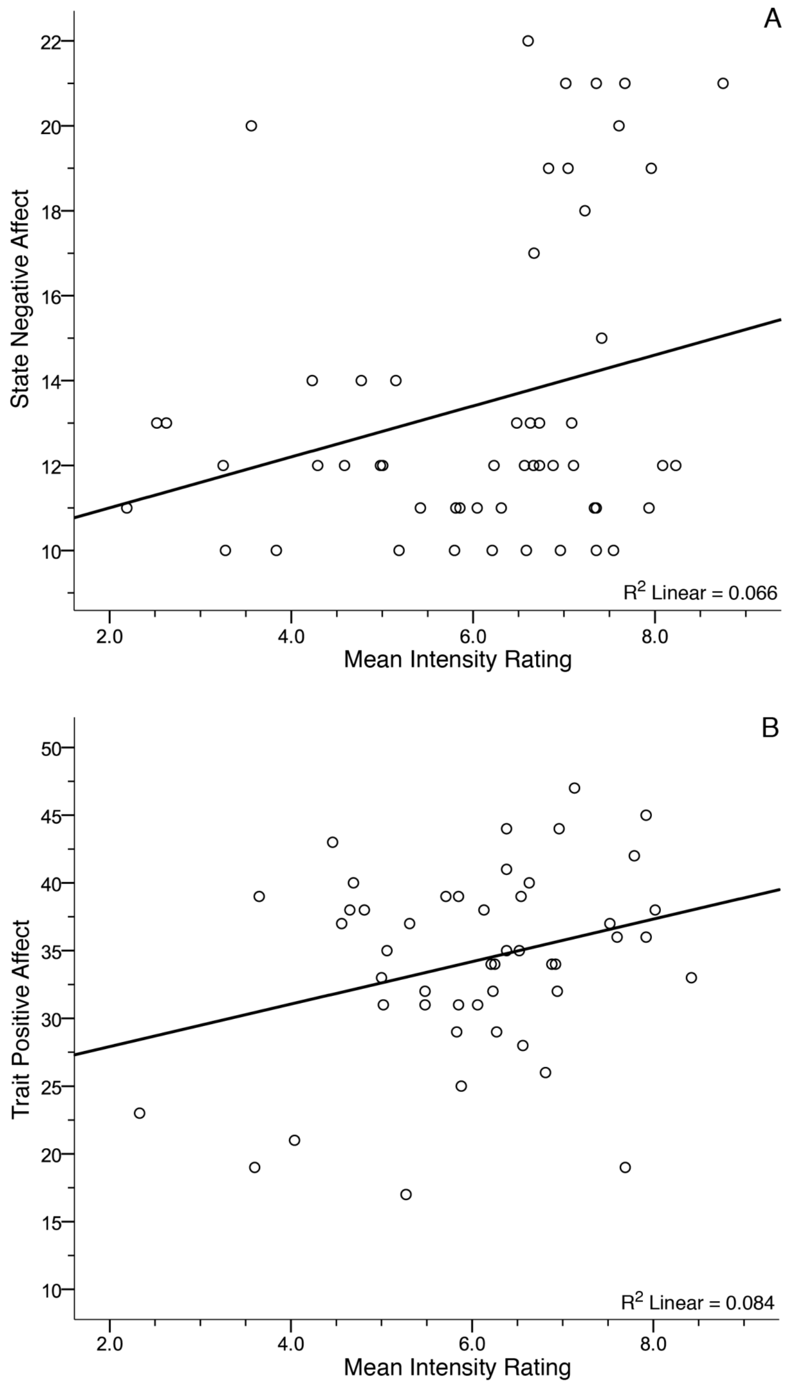

Figure 2.1. Scatterplots depicting correlations between PANAS scores and image intensity ratings. Panel A depicts the significant correlation of state negative affect and image ratings (r = .258) in Sample 1. Panel B depicts the significant correlation of trait positive affect and image ratings (r = .290) in Sample 2. Note the panels' vertical axes have different scales, as dictated by the data. For both samples, the minimum possible PANAS score for positive or negative affect was 10 (i.e., lowest possible rating of 1 on all 10 items). Image intensity ratings were based on a scale of *1* (lowest intensity) to *9* (highest intensity).

Exploratory Analysis

Given the two significant correlations in the primary analyses, an additional analysis was run to further explore the relationship between affect and emotional intensity. An additional variable was created representing the difference between the positive and negative PANAS scores (i.e., positive affect minus negative affect), referred to hereafter as affect asymmetry. An affect asymmetry score greater (less) than zero indicates the positive affect score was greater (less) than the negative affect score. Descriptives for the affect asymmetry scores were as follows: Sample 1, M = 12.89, SD = 7.01, min = -2, max = 28; Sample 2, M = 13.78, SD = 9.48, min = -5, max = 32. Correlations were run between affect asymmetry scores, and the three variables from the primary analysis (Table 2.2).

Table 2.2.

Affect Asymmetry Scores' Means, and Correlations with Primary Variables

Group	Positive affect	Negative affect	Image Rating	*M*	SD
Sample 1	.852**	-.448**	-.011	12.89	7.01
Sample 2	.792**	-.691**	.291*	13.78	9.48

Note. Affect asymmetry scores were calculated by subtracting each participant's negative affect score from his/her positive affect score. Positive and negative affect were assessed using the PANAS. Sample 1 data represents state-level affect, and Sample 2 data represents trait-level affect. All tests were two-tailed. $^*p < .05$, $^{**}p < .001$

As would be expected, there were highly significant correlations in both samples between affect asymmetry scores, and both positive and negative affect (all ps < .001). These correlations are not particularly informative, but provide context for the two samples. The correlations of interest are those between the affect asymmetry scores and image intensity ratings. In Sample 1, the correlation of affect asymmetry and image ratings was not significant, $r = -.011$, $p = .937$. Notably, in Sample 2 the correlation of affect asymmetry and image ratings was significant, $r = .291$, $p = .043$ (Figure 2.2).

Figure 2.2.

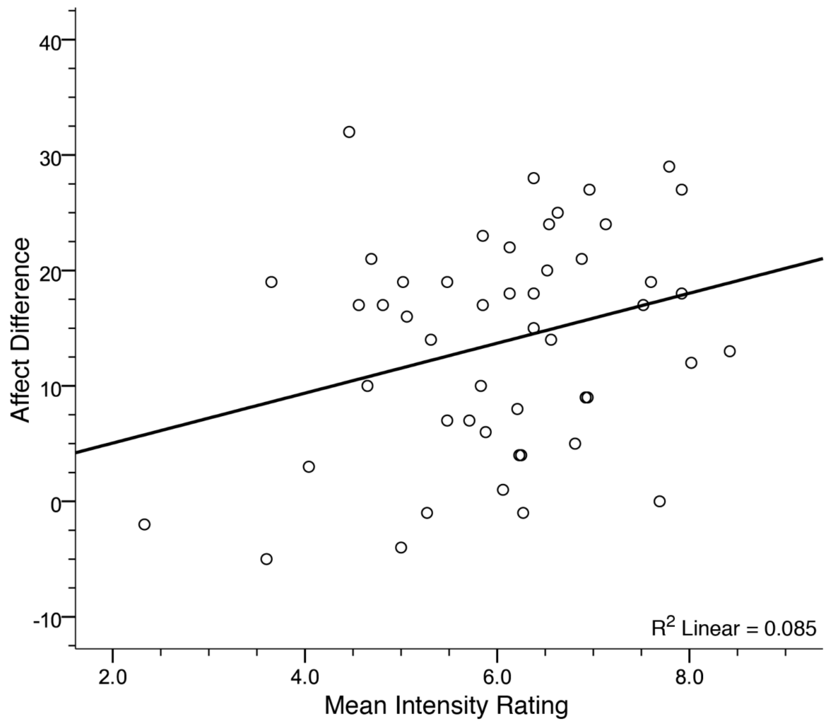

Figure 2.2. Scatterplot depicting the significant correlation of affect asymmetry and image intensity rating in Sample 2 ($r = .291$). Affect asymmetry was calculated by subtracting each participant's negative affect score from his/her positive affect score. Image intensity ratings were based on a scale of 1 (lowest intensity) to 9 (highest intensity).

Discussion

An abundance of research has examined the effect of state affect (mood) on emotions, yet the effect of trait affect on emotions has received little attention. The results of Chapter 1 suggested a positive association between trait positive affect and the intensity of negative emotional experiences. The present study sought to examine the relationship of both state and trait affect to the intensity of emotional experiences. It was hypothesized that both state negative affect and trait positive affect enhance the intensity of negative emotional experiences. As predicted, both state negative affect

(Sample 1) and trait positive affect (Sample 2) showed significant positive correlations with the respective emotional intensity ratings of each sample. An exploratory analysis found a significant positive correlation between trait affect asymmetry scores and image intensity ratings, but no correlation between state affect asymmetry scores and image intensity ratings.

The present results of Sample 1 showing a positive correlation of state negative affect and negative emotional intensity is consistent with, and extends, the existing literature on mood congruence. Numerous studies have shown that moods facilitate the processing of valence-congruent emotions and affective stimuli, across a wide array of tasks involving judgment and decision-making, memory, and free association (Blanchette & Richards, 2010). Mood-congruent effects have been observed in the lab with both induced and natural moods (e.g., Mayer et al., 1992; Rusting, 1999), as well as in the field (e.g., Forgas, 1998). Similar to the present study, Neumann et al. (2001) found a mood-congruent enhancement of the intensity of emotions elicited in the lab, across three experiments. Though, while Neumann et al. (2001) employed a mood induction technique, the present study relied on participants natural, pre-existing moods at the time of the experiment. It is worth noting that Neumann et al. (2001) also found a diminishing effect of incongruent moods on emotional intensity. However, the present study found no significant effect of positive mood on negative emotional intensity, and the correlation was in the direction of enhancement (r = .138, p = .318).

The present results of Sample 2 showing a positive correlation of trait positive affect and negative emotional intensity, provides limited evidence that the relationship observed in Chapter 1's results was not due to random error. Though a few studies suggest such a relationship, research on this is all but absent from the literature. Only one study was found that directly assessed trait affect and emotional intensity with results similar to the present study (Gessner & Filion, 2011), however, it is unpublished and has likewise not passed the scrutiny of peer-review. One study (Truong & Yang, 2014) found that older adults were higher in trait positive affect and were more affected by negative distracters on a working memory task, relative to younger adults. Truong and Yang (2014) could be interpreted to suggest the present study's finding, though the age difference between the study's two groups (older vs. younger adults) is a noteworthy confound.

Limitations

The present study's findings are limited since the data was obtained from the same sample as Chapter 1, whose previous data suggested the relationship of trait positive affect and negative emotional intensity that the present study was based on. However, there are some considerations to support the independence of the present study's results from those of Chapter 1. For one, the tasks in the two studies were quite different. In the emotion rating task of Chapter 1, instructions to participants described the task as having three distinct and unrelated parts on each trial: viewing an emotional image, providing a response to a math problem, and rating his/her mood. The most important part of the instructions was not conveying the actual connection between the emotional images and the mood ratings. In addition, the references to affect were different: participants were instructed to let their *emotions* occur naturally when viewing the image, and to rate the intensity of their *mood* at the end of the trial. In the present study's task, the connection between the emotional images and the intensity ratings was made explicit. Participants were instructed to view the image, let their emotions occur naturally, and to rate the intensity of the emotions they felt while viewing the image. Furthermore, in the emotion rating task of Chapter 1 the time between image offset and the rating response screen was 8 s, whereas in the present study's task, the rating response screen immediately followed image offset.

Second, the results showed that the intensity ratings were significantly different from the mood ratings (math, no math) in Chapter 1, using Williams' (1959) *t*-test for comparing two non-independent correlations. The correlation of the image intensity ratings to the math trial ratings, and to the no math trial ratings, were both highly significant (ps < .001). However, this in and of itself is unsurprising and uninformative, given that the two studies used the same set of images to elicit emotions. Thus, Williams' (1959) *t*-test was used to compare the two intensity rating correlations (math trial ratings correlation, and no math trial ratings correlation), to the correlation of the math trial and no math trial ratings. Results showed that both of the intensity ratings correlations were significantly weaker than the correlation of Chapter 1's math trial and no math trial ratings.

Conclusions and Future Directions

The primary goal of the present study was to further test the idea that high trait positive affect is associated with higher intensity negative emotions. While the present study was not designed to fully explain the relationship and underlying mechanisms, it does hint toward this relationship being a reliable effect, and worthy of further research. As with much of the experimental research on affect, the ecological validity of the present finding is debatable (Silvia & Warburton, 2006). It could be argued the experimental task in the present study does not reflect how emotions are encountered and experienced in everyday life. While true to an extent, the present study controlled for many factors that would inhibit a true examination of the intensity of emotional experiences in the field. In the real world, people with high trait positive affect may be predisposed to diverting attention away from negative stimuli, and in turn, they may avoid experiencing negative emotions. Mood congruence research has shown that mood influences attentional selection, with regard to both drawing attention to congruent, and diverting attention away from incongruent, affective stimuli (Becker & Leinenger, 2011; Sanchez & Vazquez, 2014; Tamir & Robinson, 2007). Furthermore, optimism, a known correlate of positive affect (Cohen & Pressman, 2006), has also been associated with selective attention toward positive stimuli and inattention to negative stimuli (Isaacowitz, 2005; Segerstrom, 2001). It serves to reason that if positive moods lead to an avoidance of negative stimuli, then those who most frequently experience positive moods (high trait positive affect) may not experience high intensity negative emotions in the real world. Diverting attention from negative stimuli is an effective emotion regulation technique that people with high trait positive affect may employ frequently (Ochsner & Gross, 2005).

Oftentimes in life, however, selective attention to negative stimuli or events is unavoidable and necessary, and how people experience those emotions is an important question. When those with high trait positive affect are faced with having to attend to negative stimuli, they may in fact exhibit higher intensity negative emotions. The present study's task required participants to attend to the negative emotional images and the emotions they felt in response. Not only was trait positive affect positively correlated with negative emotional intensity, the exploratory analysis showed that the higher the trait positive affect relative to trait negative affect, the higher the negative emotional intensity as well. This leads to several interesting questions. Do people with high trait positive affect frequently employ emotion regulation strategies involving inattention to negative stimuli? If so, does this result in less experience dealing with negative emotions? Does less experience with negative emotions entail less skill in regulating attended-to negative emotions, and result in higher intensity emotions?

While the present research leads to some interesting questions for research in the long-term, the present study would benefit from smaller steps toward refinement and replication in the near-term. Admittedly, the present study's design was not ideal. An ideal version of this study would collect both state and trait affect data from the same sample of participants. This would allow one to determine whether the effects of state negative affect and trait positive affect on negative emotional intensity would hold simultaneously. Also, it would provide a more complete understanding of the nuances and potential interactions of state and trait affect as they pertain to emotional intensity. Further expansion on the present design could include positive emotional images in the intensity rating task as well, which would help round out the overall picture between state affect, trait affect, and emotional intensity. Additional steps could include experimentally-induced moods rather than natural moods, and the use of experience-sampling field methods. Experience-sampling would provide more ecological validity by measuring the intensity of real-world emotions as they occur, and provide data that is more detailed and informative (see Kuppens, Oravecz, & Tuerlinckx, 2010; also Fleeson, 2001). Though comparing the intensities of two persons' emotions, each in response to different emotional stimuli or events, presents difficulties as well. Overall, future research to replicate and expand on the present research, and provide a fuller explanation of the present findings will certainly be illuminating.

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CHAPTER 3

ATTRACTING STEM TALENT: DO STEM STUDENTS PREFER TRADITIONAL OR WORK/LIFE-INTERACTION LABS?

Abstract

The demand for employees trained in science, technology, engineering, and mathematics (STEM) fields continues to increase, yet the number of Millennial students pursuing STEM is not keeping pace. We evaluated whether this shortfall is associated with Millennials' preference for flexibility and work/life-interaction in their careers—a preference that may be inconsistent with the traditional idea of a science career endorsed by many lab directors. Two contrasting approaches to running STEM labs and training students were explored, and we created a lab recruitment video depicting each. The *work-focused* video emphasized the traditional notions of a science lab, characterized by long work hours and a focus on individual achievement and conducting research above all else. In contrast, the *work/life-interaction-focused* video emphasized a more progressive view – lack of demarcation between work and non-work lives, flexible hours, and group achievement. In Study 3.1, 40 professors rated the videos, and the results confirmed that the two lab types reflected meaningful real-world differences in training approaches. In Study 3.2, we recruited 53 current and prospective graduate students in STEM fields who displayed high math-identification and a commitment to science careers. In a between-subjects design, they watched one of the two lab-recruitment videos, and then reported their anticipated *sense of belonging* to and *desire to participate* in the lab depicted in the video. Very large effects were observed on both primary measures: Participants who watched the *work/life-interaction-focused* video reported a greater *sense of belonging* to (d = 1.49) and *desire to participate* in (d = 1.33) the

lab, relative to participants who watched the *work-focused* video. These results suggest Millennials possess a strong desire for work/life-interaction, which runs counter to the traditional lab-training model endorsed by many lab directors. We discuss implications of these findings for STEM recruitment.

Introduction

The U.S. faces a shortage of high-level STEM (Science, Technology, Engineering, and Mathematics) talent. There are not enough qualified college graduates to fill government STEM jobs (National Academy of Engineering & National Research Council, 2012), and an increasing number of students are bypassing academic jobs in STEM disciplines (Mason, Goulden, & Frasch, 2009). In addition, the rate of STEM degrees granted to domestic students is declining (Atkinson, 2012). Overall, the demand for employees in STEM is increasing, yet the number of students pursuing STEM careers is not keeping pace. There are multiple causes of this problem (Atkinson, 2012; Mason et al., 2009). One reason is that the youngest cohorts of STEM majors, those born between late 1982 and 2000 and entering the workforce between 2005 and 2022—so-called *Millennials*—differ from their predecessors in attitudes, values, and preferences about the nature of the workplace and specifically, the optimal level of work/life-interaction (Halpern & Murphy, 2005a; Twenge, 2010).

The term *work/life-interaction*, or *work/family-interaction*, refers to the degree to which work lives and non-work or family lives are integrated, rather than confined to their respective work versus non-work domains (Halpern & Murphy, 2005a). The change in norms that occurred in the latter part of the 20th century, from families with stay-at-home moms to those with two working parents, led to the concept of work/life-balance, in which parents carefully balance their time between responsibilities to their careers and to their families (Halpern & Murphy, 2005a). The limited time resources available in a given day makes the attempt to balance work and family needs difficult, and often results in one set of needs being shortchanged when the other set demands more time and attention (Halpern & Murphy, 2005a). Thus, Halpern suggested that the unsustainability of the work/life-balance concept calls for a re-evaluation of how we view work, and more specifically, that the degree of work/life-interaction should be maximized for the benefit of employers, employees, and their families (Halpern & Murphy, 2005a). At its core, the work/life-interaction concept entails flexible working environments in which employees' non-work needs and responsibilities are recognized and accommodated by employers (Halpern & Murphy, 2005a, 2005b). An example would be allowing employees to adjust their work hours so they can pick their children up from school or day care. However, the work/life-interaction concept also entails collaborative work environments wherein employees rely on one another, and group-achievement is emphasized. A collaborative environment allows an employer to provide flexibility to its employees without sacrificing the productivity of the company itself. When a group of employees collaborate on a project, it ensures that work on the project will continue if and when one member leaves the workplace early to attend to non-work needs. Thus, both flexibility and collaboration are integral to achieving work/life-interaction, and to avoiding the pitfalls inherent in the work/life-balance concept (Halpern & Murphy, 2005a, 2005b).

Evidence suggests young STEM employees today prefer intertwined professional and personal lives within collaborative and flexible work environments. Surveys repeatedly indicate that Millennials desire greater work/life-interaction in their jobs than did previous generations (Deal, Altman, & Rogelberg, 2010; Twenge, 2010). Many view STEM careers as imbalanced toward work without regard for broader life demands, and thus opt for non-STEM careers (Mason et al., 2009). Two interesting aspects of this cultural shift are that: a) the desire for greater work/life-interaction has long been viewed as a women's issue (Mason et al., 2009), though increasingly an economic justification has been made for employers to provide such interaction for employees of both sexes (Halpern, 2005; Halpern & Murphy, 2005b), and b) the work/life-interaction view contrasts starkly with the traditional notion of the solitary, goal-oriented lifestyle of a scientist.

Some high-profile technology employers (e.g., Evernote, Google, Cisco, et al.) have embraced Millennials' desire to lead integrated, so-called "360-degree lives," embedded in an always-on corporate culture. To attract the best talent, these employers integrate employees' non-work needs with their jobs by providing flexible working conditions and a wide range of services (e.g., on-site health clubs, hair stylists, cafeteria meals for employees' families on late-working nights, automobile oil changes) that blur the traditional boundaries between work and non-work (Miller & Wortham, 2011).

In contrast, STEM fields within academia still operate largely the way they did many decades ago: A successful career requires long hours in the lab in addition to teaching, and in general, dedication to one's work above all else – including family life. This "traditional" model was sensible at a time when the vast majority of academics and Ph.D. recipients were men who were the sole income-earners in their families (Ceci & Williams, 2011; Mason et al., 2009). Today, however, women represent a steadily increasing proportion of STEM doctorate recipients. In many fields (e.g., biology, medicine, veterinary science), the number of doctoral degrees granted to women is keeping pace with or outpacing the number granted to men (Ceci & Williams, 2011). But many women have found it difficult to fulfill the demands of completing a doctorate and pursuing a tenure-track professorship at a time in life when they also aspire to have children (Williams & Ceci, 2012). Current research indicates that men in the Millennial generation are also expressing a preference for family-friendliness and flexibility in their careers (Mason et al., 2009). Simply put, the traditional academic culture may not be optimally structured to accommodate changing demographics and women who want to raise families, much less a generational change in values and preferences toward work.

It is possible that the decline in domestic STEM Ph.D.s can be partly attributed to college students' exposure to traditional academic life in STEM fields, which inadvertently skews their view of STEM careers as a whole. Many current senior science lab directors—the "Boomer" generation—were socialized in an era when life revolved around work and boundaries between work and non-work were clear (Halpern & Murphy, 2005b). However, the current cultural shift in values and preferences toward work calls for an examination of how we recruit (or fail to recruit) the most talented young people to join the scientific workforce today. Do typical recruitment and training strategies used by traditional Boomer lab directors appeal to today's talented young STEM students? Or, are we unwittingly discouraging these students from pursuing STEM careers because of these traditional views possessed by lab directors? If so, are we discouraging women more than men because of their presumed greater desire for work/life-interaction, or do Millennials of both genders equally prefer the same type of training experience?

In this study we explored whether preference for greater work/life-interaction influences talented STEM students' decisions to join a hypothetical lab for graduate training. To examine this issue, we first created two lab recruitment videos that differed in their portrayal of the graduate training experience in the lab: one video reflected the traditional notions of science in academia that focuses on work above all else, and the second video reflected a more modern perspective highlighting the principles of work/life-interaction. In Study 3.1, we recruited a sample of current faculty members to validate the two videos in terms of the videos' accuracy in portraying real-world labs and conceptually distinct approaches to graduate training. Each faculty member was asked to rate the similarity of each video to the way he or she had been trained as a graduate student, and to the way he or she trains graduate students today. In Study 3.2, each participant in a sample of current STEM students watched one of the two recruitment videos, and provided ratings of how likely he or she would be to join and how comfortable he or she would feel being a part of the lab portrayed in the video. We also evaluated whether the two videos differentially affected students' commitment to pursuing a science career.

Study 3.1

We hypothesized that a traditional work-focused approach to training graduate students, on the one hand, and an approach that incorporates more work/life-interaction, on the other hand, are two distinct types of training methods used in real-world research labs. Also, we hypothesized that the way a person was trained as a graduate student influences the way he or she later trains graduate students. That is, lab directors train graduate students in a way similar to the way they themselves were trained.

Method

Participants

A total of 62 current faculty members were contacted and asked to take part in this study. Responses were received from 40 faculty members (64.5% response rate; 15 females, 25 males). All respondents were full-time professors representing 16 different Carnegie Type 1 (research-intensive) institutions from across the U.S. The sample of respondents included representatives from the following STEM fields (in accordance with the National Science Foundation's classification of STEM fields; National Science Board, 2010, Table 3-1): biology, chemistry, economics, engineering, genetics, neurobiology, physics, psychology, and sociology. All respondents had a Ph.D., and all had experience running their own research lab and training graduate students. The mean number of years since respondents received their Ph.D. was 23.5 years (SD = 11.6, minimum = 4 years, maximum = 43 years).

Materials

We created two videos representing two different approaches to graduate training: one approach that emphasized a total commitment to the lab and to conducting research (hereafter referred to as the *work-focused lab)*, and another approach that emphasized collaboration, flexibility toward work, and accommodations for non-work needs (hereafter referred to as the *work/life-interaction-focused lab*). Each video was approximately 2 min 15 sec in length, and included a male professor/lab director (3rd author) describing the expectations for lab members, and four current graduate-student members describing their lives in the lab. The *work-focused* video emphasized the traditional notions of academia: working long hours, a competitive atmosphere, and the need for single-minded dedication to one's work above all else (e.g., a graduate student in the video states: "*This lab is really competitive, but in a good way because it pushes each individual to pursue their interests farther and farther. I feel like I'm achieving more than my friends in less competitive labs."*). In contrast, the *work/life-interaction-focused* video emphasized flexible working conditions and a collaborative atmosphere in which members were "all in it together" and had time to pursue meaningful interests outside the lab (e.g., a graduate student in the video states: "*All the students in the lab become really cohesive throughout the year. If someone is running behind getting something done at the end of the day...someone else is usually there to help them finish up so they're not working all* *night*."). Also, the *work-focused* video depicted a predominantly male lab environment (75% male lab members) since traditionally, women were underrepresented in STEM fields and continue to be underrepresented in math-intensive fields. In contrast, the *work/life-interaction-focused* video showed a gender-balanced lab environment (50% female-50% male) that reflects a key national goal of future STEM recruitment and training.

Procedure

Faculty members were contacted via email and asked to participate in an online survey made available using the Qualtrics Web Survey Tool. Each respondent to the survey rated the two lab recruitment videos according to his or her personal experiences as a graduate student and as a lab director. The two videos were simply labeled *Video 1* and *Video 2*, and each respondent was asked to rate a) how much each lab resembled his or her own graduate training experience (i.e., *How they were trained*), and b) how much each lab resembled the way he or she trains students today (i.e., *How they train their students*). Respondents provided ratings based on a five-point scale, from 1 = *Not at all*, to 5 = *Exactly*. Each respondent watched one video and rated the two response items, then watched the second video and rated the two response items again. Two versions of the Qualtrics survey were created to counterbalance the presentation order of the two videos, and these two versions were distributed equally amongst the 62 faculty members who were contacted to participate. Amongst respondents, 21 watched the *work-focused lab* video first, and 19 watched the *work/life-interaction-focused lab* video first. Data are archived and accessible at: ciws.cornell.edu.

Results

Each respondent provided ratings for four items in total: one *how they were trained* rating and one *how they train students* rating for each of the two videos (Table

3.1). We ran a set of Pearson correlations (r) that included five variables: each of the four response items, and the number of years since Ph.D. (Table 3.2). First, we evaluated the extent to which the ratings of the two videos co-varied. We hypothesized the ratings of the two videos would be inversely correlated, thus indicating that the underlying concepts are distinct from one another. As expected, we found significant inverse correlations between the resemblance of *how they were trained* to the *work-focused lab*, and to the *work/life-interaction-focused lab*, $r = -.60$, $p < .001$; as well as between the resemblance of *how they train students* to the *work-focused lab*, and to the *work/life-interaction-focused lab*, $r = -.42$, $p = .007$ (Table 3.2). These results indicate that the two approaches to graduate training depicted in the videos represent approaches used in real-world labs, and that the two approaches are conceptually distinct.

Table 3.1.

Means and Standard Deviations of Faculty Members' Ratings by Video Type

	Video Type	
Response item	Work-focused	Work/life-interaction
Faculty were trained	3.13 (1.27)	2.90 (1.13)
Students are trained	2.55 (0.99)	3.65 (0.95)

Note. Study 3.1 faculty respondents ($N = 40$) were asked to watch a *work-focused lab* video (*Work-focused*) and a *work/life-interaction-focused lab* video (*Work/life-interaction*) and rate the degree to which each video resembles (a) how they were trained as graduate students (*Faculty were trained*) and (b) how they train their own graduate students today (*Students are trained*). Ratings were based on a scale of 1 = *Not at all* to 5 = *Exactly*.

Table 3.2.

Pearson Correlations (r) of Faculty Members' Video Ratings and Number of Years Since Ph.D.

Variable	*1*	*2*	*3*	*4*
1. Faculty were trained—Work-focused	1.00	–	–	–
2. Faculty were trained—Work/life-interaction	-.602**	1.00	–	–
3. Students are trained—Work-focused	.540**	-.434**	1.00	–
4. Students are trained—Work/life-interaction	-.326*	.614**	-.419**	1.00
5. Number of Years since Ph.D.	.067	-.143	-.030	-.123

Note. A set of Pearson correlations were conducted that included five variables including two response items per each of the two videos, and the number of years since Ph.D. Study 3.1 faculty respondents ($N = 40$) were asked to watch a *work-focused lab* video (*Work-focused*) and a *work/life-interaction-focused lab* video (*Work/life-interaction*) and rate the degree to which each video resembles (a) how they were trained as graduate students (*Faculty were trained*) and (b) how they train their own graduate students today (*Students are trained*), for a total of four response items per respondent. Ratings were based on a scale of 1 = *Not at all* to 5 = *Exactly*. *Number of years since Ph.D.* is the number of years since the respondent received his or her Ph.D. at the time the survey was completed. *$p < .05$. **$p < .01$.

Next, we evaluated the developmental impact of the type of graduate training respondents had experienced—in other words, whether the way a faculty member was trained as a graduate student influences how he or she trains students today. We found strong support for this hypothesis, with positive correlations between the resemblance of *how they were trained* and *how they train students* to the *work-focused lab*, $r = .54$, $p < .001$; and between the resemblance of *how they were trained* and *how they train students* to the *work/life-interaction-focused lab*, $r = .61$, $p < .001$ (Table 3.2). In addition, we found significant inverse correlations between the resemblance of *how they were trained* to the *work-focused lab*, and the resemblance of *how they train students* to the *work/life-interaction-focused lab*, $r = -.33$, $p = .04$; and between the resemblance of *how they were trained* to the *work/life-interaction-focused lab*, and the resemblance of *how they train students* to the *work-focused lab*, $r = -.43$, $p = .005$ (Table 3.2).

Thus, lab directors who were trained using the *work-focused* approach are far more likely to train their own students using the *work-focused* approach. Likewise, those who were trained using the *work/life-interaction-focused* approach are more likely to train their own students using the *work/life-interaction-focused* approach. In sum, the results show that the two approaches are conceptually distinct (i.e., inversely correlated), and that the type of training a student receives is predictive of how he or she later trains their own students.

Given these results, we ran an exploratory analysis to determine whether a shift away from the traditional, work-focused training methods and toward more work/life-interaction-focused training methods could be detected. Specifically, we compared the correlation between the resemblance of *how they were trained* to the *work-focused lab*, and the resemblance of *how they train students* to the *work/life-interaction-focused lab*, $r = -.33$, to the correlation between the resemblance of *how they were trained* to the *work/life-interaction-focused lab*, and the resemblance of *how they train students* to the *work-focused lab*, $r = -.43$; i.e., whether it is more likely that faculty trained with the work-focused approach train their students using the work/life-interaction-focused approach, than it is that faculty trained with the work/life-interaction-focused approach train their students using the work-focused approach. The analysis was conducted using a modified version of the Pearson-Filon statistic that incorporates Fisher's r-to-z transformation (*ZPF*). The result indicated that the difference between the two correlations was not significant, $ZPF = .65$, $p = .26$.

Since all the Pearson correlation coefficients between the four response items were significant, we conducted further analyses to compare the ratings of male and female respondents. We first calculated Pearson correlation coefficients between the four response items independently for males and females. Using Fisher's r-to-z

transformation, we compared males and females on each correlation coefficient, and found no significant differences. Additionally, the number of years since Ph.D. was not significantly correlated with any of the four response items (Table 3.2).

Study 3.2

Given the results of Study 3.1, we examined whether current and prospective graduate students are differentially attracted to one type of lab over the other. Based on previous survey research (Deal et al., 2010; Twenge, 2010), we hypothesized that current and prospective graduate students in STEM fields would prefer to join labs that incorporate work/life-interaction more so than traditional work-focused labs. Specifically, we predicted that participants (both male and female) who watch the *work/life-interaction-focused lab* video would anticipate a greater *desire to participate* in and *sense of belonging* to the lab, relative to those who watch the *work-focused lab* video.

Method

Participants

A total of 102 senior-year undergraduate and first- and second-year graduate students in STEM fields at a large Carnegie Type 1 (research-intensive) university were recruited via a preliminary online survey (Time 1, T1). Time 1 participants received $10 cash compensation in return for their participation. Seventy-five of the 102 T1 participants exceeded the *math identification* threshold, which qualified them for participation in the lab-based experiment (i.e, Time 2, T2).

All 75 qualifying participants were invited to take part in T2, and 53 of the 75 participants agreed to do so (28 female, 25 male; mean age = 22.1 years, minimum = 21, maximum = 26). All 53 T2 participants were U.S.-born and native English speakers. The mean time interval between T1 participation and T2 participation was 38.2 days (SD = 11.6, minimum = 10, maximum = 58). The 53 T2 participants included representatives from the following 21 fields of study: aerospace engineering, applied mathematics, biological engineering, biology, biomedical engineering, chemical engineering, chemistry, chemical biology, computer science, earth and atmospheric sciences, earth systems, economics, engineering physics, human biology, information science, materials science and engineering, mathematics, mechanical engineering, physics, structural engineering, and transportation systems engineering. Time 2 participants included 28 undergraduate seniors (14 female, 14 male), and 25 first- and second-year graduate students (14 female, 11 male). Via random assignment, 26 participants were assigned to watch the *work-focused lab* recruitment video (12 undergraduates: 6 female, 6 male; 14 graduates: 8 female, 6 male), and 27 participants were assigned to watch the *work/life-interaction-focused lab* recruitment video (16 undergraduates: 8 female, 8 male; 11 graduates: 6 female, 5 male). Time 2 participants received an additional $25 cash compensation.

Materials

We used the two lab recruitment videos validated in Study 3.1: the *work-focused lab* video and the *work/life-interaction-focused lab* video.

T1 Survey

The T1 survey was available online using the Qualtrics Web Survey Tool. The survey included items from two measures: *math identification* and *commitment to science* (Table 3.3). Demographic information was also obtained. The *math identification* measure consisted of two statements (e.g., *I am good at math tasks*) similar to previous research in this area (Murphy, Steele, & Gross, 2007). Participants rated their level of agreement with each statement on a 7-point scale, ranging from *Not at all* to *Extraordinarily*. Each participant's *math identification* score was the sum of his or her two ratings. The *commitment to science* measure also consisted of two statements rated on the same 7-

point scale. Each participant's *commitment to science* score was the sum of his or her two ratings. Consistent with previous research that required highly math-identified participants (Murphy et al., 2007), T1 participants were required to have a *math identification* score of 10 or higher to qualify for participation at T2.

T2 Experiment

Time 2 participants were not aware of the true purpose of the experiment. Each participant was simply told that he or she would be assessing the effectiveness and quality of a science lab recruitment video as part of a study to improve recruitment into STEM fields. Each participant was randomly assigned to watch one of two lab recruitment videos differing in portrayal of the lab environment: a *work-focused lab* or a *work/life-interaction-focused lab*. Each participant completed T2 individually.

After viewing the video, each participant completed a series of survey items (Table 3.4) that included the *commitment to science* measure from T1 (Table 3.3). Two questions pertained to the supposed purpose of the experiment (e.g., *How successful would you be after working in this lab?*). These questions also served as a control check on the two videos' similarity, in terms of participants' perceptions of how effective the labs are in helping student members become successful and get the jobs they seek (Table 3.4). Another eight questions comprised the two four-question primary measures: *sense of belonging* and *desire to participate* (Table 3.4) (Murphy et al., 2007). *Sense of belonging* assessed the extent to which participants would feel like they belong in the lab, if they joined (e.g., *How comfortable do you anticipate feeling in this lab?*). *Desire to participate* assessed participants' willingness to join the lab (e.g., *How likely would you be to actually join this lab?*). All questions were answered using the same 7-point scale used in the T1 survey.

Table 3.3

Time 1 Survey Items

Math Identification
I am good at math tasks.
It is important to me that I do well on math tasks.
Commitment to Science
I am committed to pursuing a career in a STEM field.
A career in a STEM field is well suited to my particular strengths and abilities.

Note. Items were presented to Study 3.2 participants without the measures' labels depicted here. Participants were instructed to rate each item, using a 1-7 scale (*1 = Not at all, 2 = Slightly, 3 = Somewhat, 4 = Generally, 5 = Very, 6 = Extremely, 7 = Extraordinarily*). Commitment to Science was also included in the Time 2 survey. Participants' score on each measure was the sum of his or her ratings of the respective two statements of each measure.

Table 3.4

Time 2 Survey Questions

Control Check
How successful would you be after working in this lab?
How much would this lab prepare you to get the job you seek?
Sense of Belonging
Do you anticipate feeling like you would belong as a member of this lab?
How comfortable do you anticipate feeling in this lab?
How much do you feel like you could "be yourself" in this lab?
How accepted do you think you will feel in this lab?
Desire to Participate
How interested are you in this lab after watching the video?
How likely would you be to actually join this lab?
How appealing would this lab be to the typical student?
How much do you want to join this lab?

Note. Items were presented to Study 3.2 participants without the measures' labels depicted here. Participants were instructed as follows: *Please answer the following questions about the lab depicted in the recruitment video you watched, using the following scale, 1 = Not at all, 2 = Slightly, 3 = Somewhat, 4 = Generally, 5 = Very, 6 = Extremely, 7 = Extraordinarily.* Time 2 survey also included Commitment to Science (see Table 1.3). Participants' score on each of the Sense of Belonging and Desire to Participate measures was the average of his or her ratings of the respective four statements of each measure (See Table 1.5 and Figure 1.1 for results).

On both primary measures, scores were calculated for each participant by summing the ratings of the respective four statements of each measure. Also, the *commitment to science* measure was completed a second time (first completed at T1) to determine whether viewing the video altered students' plans to pursue a scientific career. Upon completion of the questionnaires, each participant was debriefed and informed of the true purpose of the experiment.

Results

Commitment to Science

Commitment to science was assessed at both T1 and T2, providing the means for a within-subjects pre-/post-manipulation comparison of the effect of watching the recruitment video on participants' commitment to science. A three-way univariate analysis of variance (ANOVA) was conducted with participant gender (male, female), video type (work-focused, work/life-interaction-focused), and time point (T1, T2) entered as the three fixed factors. Both participant gender and video type were between-subjects factors, and time point was a within-subjects factor. The analysis did not reveal any significant effects. Descriptively, scores increased slightly from T1 to T2, however, these differences were not statistically significant (Table 3.5).

Control Check

Two T2 questions were analyzed to determine the equivalency of the two videos on factors—other than the *work-focused* vs. *work/life-interaction-focused* manipulation—that could affect participants' *sense of belonging* and *desire to participate* ratings, and potentially confound the results. Each question was analyzed using an independent samples t-test. Participants' perception of how successful they would be after working in the lab did not differ between those who watched the *work-focused lab* video, $M = 4.42$, and those who watched the *work/life-interaction-focused lab* video, $M = 4.59$, $t(52) = -.54$, p

= .59. Participants' perception of how well the lab would prepare them to get the job they seek also did not differ between those who watched the *work-focused lab* video, M = 4.15, and those who watched the *work/life-interaction-focused lab* video, $M = 3.85$, $t(52) = .92$, $p = .36$. Thus, any observed differences between the two lab types on the primary measures cannot be attributed to one lab being perceived as a better source of preparation for a science career than the other—both the *work-focused lab* and the *work/life-interaction-focused lab* were perceived as good sources of preparation.

Table 3.5

Means and Standard Deviations of Commitment to Science Scores at Times 1 and 2

		Time 1	Time 2
Participant	*N*	*M (SD)*	*M (SD)*
		Work-focused	
Female	14	12.29 (1.59)	12.93 (1.44)
Male	12	12.17 (1.47)	12.25 (1.91)
Total	26	12.23 (1.51)	12.62 (1.68)
		Work/life-interaction	
Female	14	11.14 (2.18)	11.71 (1.63)
Male	13	11.85 (3.18)	12.00 (2.48)
Total	27	11.48 (2.68)	11.85 (2.05)

Note. Commitment to Science was assessed both before (Time 1, or T1) and after (Time 2, or T2) the experimental manipulation, and consisted of two statements pertaining to a commitment to pursuing a career in a STEM field. The manipulation took place in the beginning of T2, in which each participant viewed either the *work-focused lab* video ("Work-focused") or the *work/life-interaction-focused lab* video ("Work/life-interaction"). Both before and after viewing one of the videos, each participant rated his or her level of agreement with each statement on a scale of 1 = *Not at all*, to 7 = *Extraordinarily*. Scores are the sum of each participant's two ratings per time point (T1, T2). Data in each cell of the Time 1 and Time 2 columns in this table depict the mean score with the standard deviation in parentheses.

Sense of Belonging

Sense of belonging scores were analyzed in a three-way univariate ANOVA with participant gender (male, female), video type (work-focused, work/life-interaction-focused), and student status (undergraduate, graduate) entered as the three, between-subjects fixed factors. (See Appendix B for full breakdown of the *sense of belonging* means and standard deviations.) This analysis revealed only one significant effect: a large main effect of video type, $F(1, 45) = 26.0$, $p < .001$, Cohen's $d = 1.49$ (Figure 3.1). We conducted follow-up contrasts within each of the other two factors (participant gender and student status) to further examine this main effect. All follow-up contrasts were conducted using independent samples *t*-tests, and all were statistically significant. Within-gender follow-up contrasts confirmed that both female participants and male participants who watched the *work/life-interaction-focused lab* video reported a greater *sense of belonging* to the lab relative to their same-sex counterparts who watched the *work-focused lab* video, $t(45) = 4.50$, $p < .001$, and $t(45) = 2.77$, $p = .008$, respectively. Within-status follow-up contrasts confirmed that both undergraduate participants and graduate participants who watched the *work/life-interaction-focused lab* video reported a greater *sense of belonging* to the lab relative to their same-status counterparts who watched the *work-focused lab* video, $t(45) = 3.51$, $p = .001$, and $t(45) = 3.70$, $p = .001$, respectively.

Desire to Participate

Desire to participate scores were analyzed in a three-way univariate ANOVA with participant gender (male, female), video type (work-focused, work/life-interaction-focused), and student status (undergraduate, graduate) entered as the three, between-subjects fixed factors. (See Appendix B for full breakdown of the *desire to participate* means and standard deviations.) This analysis also revealed only one significant effect: a large main effect of video type, $F(1, 45) = 22.8$, $p < .001$, $d = 1.33$ (Figure 3.1).

Figure 3.1.

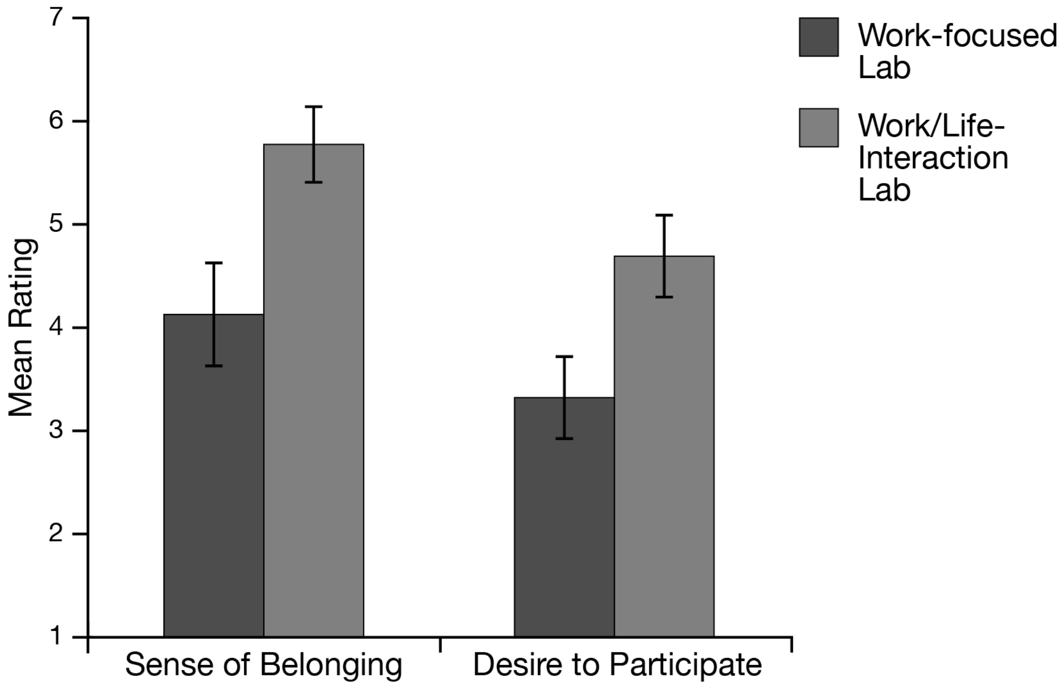

Figure 3.1. Sense of Belonging and Desire to Participate Ratings by Video Type. Student participants were randomly assigned to watch either the *work-focused lab* recruitment video or the *work/life-interaction-focused lab* recruitment video. After viewing the video, each participant completed two four-question measures in which he or she rated his or her anticipated *sense of belonging* to the lab in the video if he or she were to join, and his or her *desire to participate* in the lab in the video. Ratings were based on a 7-point scale from 1 = *Not at all* to 7 = *Extraordinarily*. Bars in the figure represent the mean rating for each measure, by video. For each measure, the mean difference between the two video types was statistically significant. Error bars +/- 2 standard errors.

We conducted follow-up contrasts within each of the other two factors (participant gender and student status) in order to further examine this main effect. All follow-up contrasts were conducted using independent samples *t*-tests, and all were statistically significant. Within-gender follow-up contrasts confirmed that both female participants and male participants who watched the *work/life-interaction-focused lab* video reported a greater *desire to participate* in the lab relative to their same-sex counterparts who watched the *work-focused lab* video, $t(45) = 3.91$, $p < .001$, and $t(45) = 2.88$, $p = .006$, respectively. Within-status follow-up contrasts confirmed that both undergraduate participants and graduate participants who watched the *work/life-interaction-focused lab* video reported a greater *desire to participate* relative to their same-status counterparts who watched the *work-focused lab* video, $t(45) = 2.12$, $p = .04$, and $t(45) = 4.57$, $p < .001$, respectively.

General Discussion

The results of Study 3.1 showed that the approaches to graduate training depicted in the *work-focused* and *work/life-interaction-focused* videos are conceptually distinct approaches used by current lab directors in real-world labs. As seen, the type of labs that current lab directors were trained in has a long reach, influencing the kind of lab experience they create for their own students today. The results of Study 3.2 suggest that current and prospective STEM graduate students with high levels of math identification are less interested in joining science labs portrayed in traditional ways, than they are in joining labs with more work/life-interaction. Participants who watched the *work/life-interaction-focused lab* video reported a greater *sense of belonging* to and *desire to participate* in the lab depicted in the video, compared to participants who watched the *work-focused lab* video. Both effects were quite large, and occurred despite the fact that participants rated both labs similarly in terms of how successful they would be after working in the lab and how well the lab would prepare them to get the job they seek. In addition, neither video had any effect on participants' *commitment to science*: Participants in both conditions were strongly committed to a career in science, both before and after the experimental manipulation.

These findings suggest that senior scientists who endorse the attitudes and goals of the *work-focused lab* could lose talent to other labs, provided that *work/life-interaction-*

focused labs are an option. Moreover, if the traditional, work-focused approach is the only option available, students could induce that it is the only way labs are run, and science in general could lose talent to non-scientific careers that are better adapted to Millennials' desire for work/life-interaction. And, as was found in Study 3.1, one generation's approach to graduate training can have a lasting impact, given that scientists are likely to train graduate students in a manner similar to the way they themselves were trained.

These studies support the view that Millennials entering graduate school in STEM fields, such as the participants in Study 3.2, seek environments characterized by work/life-interaction (Deal et al., 2010; Twenge, 2010), and show that this preference exists independently of how well these students believe the labs prepare them for later careers. Once hailed as primarily a woman's desire (Ceci & Williams, 2011; Mason et al., 2009; Williams & Ceci, 2012), our findings reveal that the preference for work/life-interaction is now shared by men, a point recently observed across many fields, including STEM, medicine, and law (Howell, Beckett, Nettiksimmons, & Villablanca, 2012). In addition to changing workforce demographics, this shift in attitudes and preferences toward work/life-interaction may also relate to changing norms for division of household labor among educated couples (Ceci & Williams, 2011; Williams & Ceci, 2012). Time for family, travel, and relaxation are more important to both female and male Millennials than was true of previous generations (Howell et al., 2012; Galinsky, Aumann, & Bond, 2009; Twenge, 2010). Traditional sources of advice for graduate students such as *The Compleat Academic* (Darley, Zanna, & Roediger, 2003)—that recommend a consuming, linear approach to graduate training—may not appeal to many of today's students. Millennials have different expectations than members of the "Boomer" generation who now run most labs (Mason et al., 2009), and consequently, the latter should be aware of this cultural shift. The problem of reaching and attracting the best talent in the current cohort of students may require a new approach, and raises intriguing issues regarding feasibility and productivity that, although beyond the scope of this experiment, should be discussed by members of professional scientific associations.

It may be easier to accommodate Millennials' desire for work/life-interaction in some fields than in others in which the demands for stringent lab hours can be crucial for the conduct of research. The philosopher Sommers (2008), responding to women's demand for greater work/family-interaction, noted that some have labeled traditional male scientists' work habits as representing obsessive, single-minded dedication, with an "intense desire for achievement" that some allege not only marginalizes women, but also may compromise good science. Paraphrasing one gender activist, Sommers reports, "If we continue to emphasize and reward always being on the job, we will never find out whether leading a balanced life leads to equally good or better scientific work" (Sommers, 2008). She is, however, critical of this view noting that, "A world where women (and re-socialized men) earn Nobel Prizes on flextime has no relation to reality" (Sommers, 2008). We take no position in this debate beyond noting that perhaps in some fields it will be difficult and/or undesirable to deemphasize the "obsessive" work habits and single-minded dedication that characterize traditional, work-focused labs. We leave it to scientists and their professional societies to determine whether the desire of today's talented students for greater work/life-interaction can be accommodated within the strictures of their graduate training models without compromising scientific progress.

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APPENDICES

APPENDIX A

Table 1.

Images' Normative Affective Intensity Ratings by Image Group

Group 1		Group 2	
Image	Rating	Image	Rating
9040	6.05	9410	6.00
6570	5.58	3120	5.85
2800	5.43	9810	5.65
9433	5.43	9042	5.50
3181	5.40	6313	5.28
6212	5.40	9570	5.25
9400	5.40	3030	5.20
6550	5.28	3530	5.15
2053	5.25	2661	5.13
3301	5.10	9921	5.10
3250	5.03	6560	5.03
9571	4.95	2205	5.00
9490	4.93	6838	4.95
9250	4.90	6350	4.88
9300	4.80	3500	4.78
6540	4.78	9800	4.78
8480	4.73	9520	4.70
9050	4.70	9561	4.65
3160	4.68	3550	4.60
6360	4.65	9140	4.60
6211	4.55	6260	4.58
9181	4.45	3230	4.43
9910	4.43	9430	4.40
9182	4.33	3300	4.38

Note. The negative emotional images were a sub-set of the IAPS (Lang et al., 2008). For counterbalancing purposes, the images were split into two approximately equal groups in terms of the images' emotional intensity, based on the normative ratings obtained by Mikels et al. (2005). *Image* refers to the original IAPS image numbers, and *rating* refers to Mikels et al.'s (2005) normative affective intensity ratings. *Group 1* images were presented on math trials and *group 2* images on no-math trials for half of participants, and vice versa for the other half of participants.

Table 2.

Math Task Expressions

One Operation		Two Operations	
Expression	Correct	Expression	Correct
7 + 6 = 11	False	(12/3) + 2 = 14	False
3 + 8 = 12	False	(4/2) + 7 = 6	False
2 * 9 = 24	False	(1*8) + 6 = 18	False
16 / 3 = 4	False	(3*4) - 7 = 8	False
6 - 5 = 2	False	(7*3) - 9 = 15	False
8 / 1 = 7	False	(10/2) - 7 = 15	False
6 + 9 = 15	True	(8/4) + 1 = 3	True
5 * 4 = 20	True	(6/3) + 5 = 7	True
2 * 7 = 14	True	(9*1) - 5 = 4	True
15 / 5 = 3	True	(12/2) - 4 = 2	True
13 - 8 = 5	True	(14/2) - 7 = 0	True
10 - 3 = 7	True	(9/3) - 1 = 2	True

Note. Math task expressions consisted of either one or two mathematical operations, and each required a response indicating whether it was true or false. *Expression* is the expression presented to participants, and *correct* indicates whether the correct response was true or false. One expression was presented per math trial. The 24 math expressions were presented randomly to each participant across the math trials in both blocks of real trials (12 math trials per block).

APPENDIX B

Means and Standard Deviations for Sense of Belonging and Desire to Participate, by Video Type, Participant Gender, and Student Status

		Work-focused		Work/life-interaction	
Gender	Status	*N*	*M (SD)*	*N*	*M (SD)*
		Sense of Belonging			
Female	Undergraduate	6	2.92 (1.19)	8	5.12 (0.94)
	Graduate	8	2.94 (1.33)	6	4.63 (0.70)
	Total	14	2.93 (1.23)	14	4.91 (0.86)
Male	Undergraduate	6	3.88 (1.25)	8	4.70 (1.33)
	Graduate	6	2.83 (1.27)	5	4.55 (0.57)
	Total	12	3.35 (1.32)	13	4.64 (1.07)
Total	Undergraduate	12	3.39 (1.27)	16	4.91 (1.13)
	Graduate	14	2.89 (1.26)	11	4.59 (0.62)
	Total	26	3.13 (1.26)	27	4.78 (0.96)
		Desire to Participate			
Female	Undergraduate	6	2.67 (1.02)	8	3.81 (1.29)
	Graduate	8	2.03 (0.89)	6	4.00 (0.97)
	Total	14	2.30 (0.97)	14	3.89 (1.13)
Male	Undergraduate	6	2.71 (1.29)	8	3.25 (0.96)
	Graduate	6	2.00 (0.99)	5	3.90 (0.72)
	Total	12	2.35 (1.16)	13	3.50 (0.91)
Total	Undergraduate	12	2.69 (1.11)	16	3.53 (1.14)
	Graduate	14	2.02 (0.90)	11	3.95 (0.83)
	Total	26	2.33 (1.04)	27	3.70 (1.03)

Note. Sense of Belonging (*SB*) and Desire to Participate (*DP*) each consisted of four statements, and gauged participants' anticipated sense of belonging to and desire to participate in the lab depicted in the video (respectively). SB and DP were completed after watching either the *work-focused lab* video (*Work-focused*) or the *work/life-interaction-focused lab* video (*Work/life-interaction*). Participants rated each statement on a scale of 1 = *Not at all*, to 7 = *Extraordinarily*, and a participant's score on each measure was the mean of his or her ratings of the four respective statements of each measure. *Status* refers to the participant's status as either an undergraduate or graduate student at time of survey.