Cognitive Demands Associated with the Use of Cognitive Reappraisal to Regulate Positive and Negative Emotion

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Abstract

As cognitive reappraisal is an effortful process, differences in cognitive demand could help to explain how and when the emotion regulation strategy is executed, such as among individuals with fewer cognitive resources. While some studies have already suggested that increasing and decreasing one's responses to emotional information are more effortful goals than the passive viewing of emotional information, these studies have not looked across multiple regulation and valence conditions, failing to reflect the variety of emotional situations we face in daily life. In the present study, pupil diameter was measured as an index of cognitive demand as 63 undergraduate students increased, decreased, and maintained their emotional response towards pleasant and unpleasant stimuli. We hypothesized that (1) increasing and decreasing one's emotional response would result in significantly greater pupil dilation than passive viewing, and (2) increasing one's emotional response would result in greater pupil dilation than decreasing. Although the hypotheses were not supported by the data, the analysis showed that the *maintain* instruction elicited greater pupil dilation than the *decrease* instruction during the instruction portion of the trial. This result might suggest that cognitive reappraisal, if anything, is less cognitively demanding than passively viewing emotional stimuli. More likely, however, is that this result is due to a limitation of the study design.

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Regulating our emotions is a common process that we carry out in our daily lives. Whether we are holding back our tears during a sad film or heightening our surprise for a gift, we frequently use emotion regulation to adapt to different situations. There are various ways of regulating emotion, such as cognitive reappraisal. Through cognitive reappraisal, an individual reinterprets a situation such that the emotion felt towards an event is changed, or reappraised (Gross, 1998). For example, instead of feeling disgusted during a violent fight scene in a movie, you can remind yourself that what you are watching is a scripted scene and thus you can reduce the disgust you feel towards it.

Within cognitive reappraisal, individuals have the ability to increase or decrease their emotional response towards an event. Decrease reappraisals seek to lessen the emotion felt towards the stimulus or to distance the viewer from the emotional experience (Ochsner & Gross, 2004; Shiota & Levenson, 2009). For example, instead of feeling bad after a rejection for a job interview, you can lessen the extent to which you feel the rejection by telling yourself that you did not really want the job anyway. Increase reappraisals heighten the emotional experience of an event such that a negative emotion will become more negative or a positive emotion will become more positive (Ochsner & Gross, 2004; Ray, McRae, Ochsner, & Gross, 2010). A good example of this might be focusing on the positive elements of a family trip in order to excite yourself even more for the event. Within the cognitive reappraisal literature, studies have suggested that the emotion regulation strategy is an effortful, or cognitively demanding, process.

With regards to cognitive reappraisal, studies have used self-reports that indirectly look at cognitive demand by measuring reported differences in emotional experience after carrying out reappraisal. Schmeichel, Volokhov, & Demaree (2008) divided participants into a Higher Working Memory Capacity group (HWMC) and a Lower Working Memory Capacity (LWMC) group based on the operation span task. When instructed to reappraise, researchers found that those with HWMC were more successful in reappraising sad and humorous stimuli than those with LWMC. Since higher levels of cognitive resources promote greater success in reappraising, this study suggests that cognitive reappraisal is indeed a cognitively demanding task. However, this inference is indirect and subjective. Needed are studies that objectively measure cognitive demand while participants reappraise.

A helpful, objective measure in understanding the cognitive demand associated with reappraisal is skin conductance level (SCL). Past studies have found skin conductance to be an index of cognitive demand (Kahneman, Tursky, Shapiro & Crider, 1969; Cohen & Waters, 1985) and recent studies related to ergonomics have relied on SCL for this purpose. For instance, a study conducted by Mehler, Reimer, and Coughlin (2012) manipulated cognitive load using a digit recall task. The study found that as the difficulty level of the digit recall task increased, so did SCL, presumably reflecting the increase in cognitive demand.

While SCL can be used as an index of cognitive demand, it is more commonly used as an index of arousal within the emotion regulation literature (Van Olst, Orlebeke, & Fokkema, 1967; Martini & Bartholomew, 2003). As such, there is a bit of uncertainty as to whether SCL findings reflect arousal or cognitive demand. With regards to arousal, several studies have shown that SCL increases when participants use cognitive reappraisal to

enhance their emotional response to stimuli as opposed to passively viewing the stimuli, particularly unpleasant stimuli (Eippert, Veit, Weiskopf, Erb, Birbaumer, & Anders, 2007; Urry, 2009; Urry, 2010; Kim and Hamann, 2012). While the literature surrounding cognitive reappraisal and pleasant stimuli is sparse, Giuliani, Mc Rae, and Gross (2008) found that decreasing one's emotional response to amusing film clips resulted in greater SCL than passively viewing the film clips. Although the researchers of these studies recorded SCL as a measure of arousal, the findings are consistent with the idea that cognitive reappraisal is a cognitively demanding task.

Pupil dilation is another physiological measure that has been shown to be an index of cognitive demand (Siegle, Ichikawa, Steinhauer, 2008; Matthews, Middleton, Gilmartin, & Bullimore, 1991). With regards to cognitive reappraisal, Urry, van Reekum, Johnstone, and Davidson (2009) conducted a study with older participants (aged 64 – 66) and recorded pupil dilation as an index of cognitive demand. Participants were instructed to *increase*, *decrease*, or *maintain* their emotional experience to unpleasant pictures. By comparing the temporal trajectory of the pupil dilation, Urry et al. (2009) showed that both decreasing and increasing one's response to unpleasant stimuli required more cognitive effort than the *maintain* instruction as reflected in pupil dilation. These findings corroborate an earlier study conducted by Urry et al. (2006) that also found that *increase* and *decrease* reappraisals resulted in greater pupil dilation than the passive viewing of unpleasant stimuli. Additionally, the study found that in the early and middle stages of the reappraisal process, the *increase* instruction resulted in greater pupil dilation than the *decrease* instruction, reflecting a difference in cognitive demand between the two reappraisal goals within a certain window of time.

From what we've seen in studies related to cognitive demand, autonomic measures and self-reports indicate that reappraisal is more cognitively demanding than the passive viewing of emotional stimuli (Giuliani et al., 2008; Schmeichel, Volokhov, & Demaree, 2008; Urry et al., 2009). However, the previously mentioned studies do not present a full picture of the cognitive demands associated with cognitive reappraisal. For instance, the studies related to SCL make it difficult to determine whether the findings reflect measures of arousal or measures of cognitive demand given that SCL can be used for both purposes. With regards to Schmeichel et al. (2008), working memory capacity seemed to facilitate successful reappraisal, which might indicate that cognitive reappraisal is a demanding task, but this is an indirect and subjective inference. While Urry et al. (2006, 2009) took a more objective approach by recording pupil dilation, the participants were all older adults (aged 64 – 66), an age group with fewer cognitive resources than younger adults (Salthouse, 2004). Given these differences, it is possible that these same findings do not apply to younger adults. Cognitive demand aside, several studies in the cognitive reappraisal literature have focused on regulating negative emotions, but few have looked at cognitive reappraisal and positive emotions. It is important to examine both positive and negative emotions in order to better reflect the wide range of emotional experiences we face and regulate in daily life. As such, the present study aims to use objective measures to examine the cognitive demands associated with *increase* and *decrease* reappraisals across pleasant and unpleasant images with a younger age group.

Similar to Urry et al. (2006, 2009), in the present study, we recorded pupil dilation to measure cognitive demand while participants used reappraisal to *maintain*, *increase*, and *decrease* their emotional responses to pleasant and unpleasant images. After the

presentation of each image, participants were asked to rate the intensity and valence of the image as a means of measuring reappraisal success. Consistent with findings from Urry et al. (2006, 2009), we hypothesized that both of the cognitive reappraisal goals would result in greater pupil dilation in comparison to the passive viewing of the stimuli. Additionally, based on the findings of pupil dilation from Urry et al. (2006), our second hypothesis was that increase reappraisals would result in greater pupil dilation than decrease reappraisals. The use of both pleasant and unpleasant images in the present study allowed us to determine whether or not these hypotheses would vary as a function of valence.

Method

Participants

Sixty-three undergraduate students from Tufts University (45 female; ages ranging between 18 and 21 years, mean = 19.10 years, *SD* = 1.65 years) participated in the study for course credit. Participants were 69.8% Caucasian, 23.8% Asian or Asian American, 7.97% Black or African American, 1.6% Pacific Islander, and 1.6% declined to provide this information. Of the total sample, 9.5% indicated they were of Hispanic origin. All study procedures were approved by the Institutional Review Board at Tufts University and all participants provided written informed consent prior to participating in the study. Two participants requested to end the task early and, as such, complete pupil data were not acquired for the participants.

Materials and Procedures

Stimuli. A total of 250 pictures were chosen from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008) designed to elicit the respective emotional responses within participants: 100 neutral (valence = 5.34, SD = 0.50; arousal = 3.39; SD = 0.69), 75 positive (valence = 6.64; SD = 0.74; arousal = 4.85, SD = 0.85), and 75 negative (valence = 2.65, SD = 0.82; arousal = 5.89; SD = 0.68). Based on IAPS ratings of arousal, the pictures showed a main effect of valence on the ratings, $F(4, 494) = 292.47$, $p < .001$. For ratings of valence, positive pictures were rated as more positive than neutral pictures ($p < .001$) and negative pictures ($p < .001$), and negative pictures were rated less positive than neutral pictures ($p < .001$). For ratings of arousal, negative pictures were rated as more arousing than positive pictures ($p < .001$) and neutral pictures ($p < .001$), and positive pictures were rated as more arousing than neutral pictures ($p < .001$). Positive pictures depicted such things as erotic scenes, families, and scenery. Negative pictures depicted such things as assaults, weapons, and deaths. Neutral pictures depicted such things as mushrooms, common objects like a drinking glass, and office supplies. An additional 5 unpleasant and 5 pleasant pictures were chosen for the practice trials that participants completed in order to familiarize themselves with the task.

Ratings. Subjective ratings of arousal for the stimuli were provided on a scale ranging from 1 (mildly intense) to 4 (very intense) after the presentation of each picture. Subjective ratings of valence were also provided on a scale ranging from 1 to 3 (pleasant, neutral, unpleasant, respectively).

Design of Cognitive Reappraisal Task. Stimuli were presented using E-prime software (version 1.1.4.1, Psychology Software Tools, Inc., Pittsburgh, PA, USA). Participants were initially presented with a slide of instructions explaining how to *decrease*, *increase*, or

maintain their emotional response towards a picture (See Appendix for exact instructions from the slide). Following the instruction, participants completed 10 practice trials to familiarize them with the instructions: 5 trials for *increase* and 5 trials for *decrease* with a mix of pleasant and unpleasant photos. The pictures used in the practice trials were not used for the test trials.

The test trials were constructed in six blocks: 1) Increase Positive + Maintain Neutral (50 trials each), 2) Decrease Positive + Maintain Neutral (50 trials each), 3) Increase Negative + Maintain Neutral (50 trials each), 4) Decrease Negative + Maintain Neutral (50 trials each), 5) Maintain Positive (25 trials), and 6) Maintain Negative (25 trials). Conditions were presented in random order within blocks, as applicable and blocks were presented in random order. Neutral pictures were always assigned the *maintain* instruction as there was no emotion to be regulated.

As depicted in Figure 1, each trial began with an instruction slide (either *increase, decrease,* or *maintain*), followed by a fixation cross, and then presentation of the stimulus in response to which they were instructed to regulate their emotional response using the instruction provided at the start of the trial. Following the 2-second stimulus, participants were instructed to indicate the stimulus' intensity and valence by keyboard press. Once participants indicated their response, a "Relax" slide appeared before the beginning of the next trial, allowing participants to briefly rest between trials.

Between every two blocks, participants were allowed to take a break for an unspecified amount of time and indicated when they were ready to continue by pressing the spacebar of the keyboard. At the end of the experiment, participants completed questionnaires: demographics, Attentional Control Scale (ACS, Derryberry & Reed, 2002),

State-Trait Anxiety Inventory (STAI-T, Spielberger, 1989), Emotion Regulation (ERQ, Gross & John, 2003). Upon completion, participants were debriefed and thanked for their participation.

Pupil Diameter. To track pupil dilation, participants' seats were adjusted such that they were within 60cm of the Tobii Eyetracker (Tobii Technology, Danderyd, Sweden; sampled at 60 Hz). Once they were correctly positioned, participants' eyes were calibrated for recording. The E-Prime script was set to automatically record eyetracking at the beginning of the script. Pupil diameter was recorded for both the right and left pupil in millimeters, reflecting real pupil diameter values as closely as possible. The averages of the right and left pupils were computed and missing values were interpolated.

Data Reduction. Prior to analysis, data for pupil dilation and picture ratings were averaged across trials separately for each of the conditions. Averages for pupil dilation were computed for half-second windows of time for the 1-second relax period, 2-second instruction period, 1-second fixation period, and 2-second picture presentation period. These means were then subjected to repeated measures GLMs. The findings below report the results of Multivariate Tests and follow-up post hoc tests where applicable.

Results

Manipulation Check. Prior to hypothesis testing, we first examined whether participants successfully reappraised their positive and negative emotions as instructed.

Self-reported ratings of arousal were used to determine whether increase and decrease reappraisals led to higher and lower arousal in comparison to the *maintain* instruction, respectively. A multivariate GLM revealed a significant effect for reappraisal

instruction, $F(2, 60) = 32.925$, $p < .001$. Across the negative and positive conditions, a post-hoc test (Fisher's Least Significant Difference) revealed that *increase* ($M = 2.42$, $SE = .05$) showed greater ratings of arousal than *decrease* ($M = 2.02$, $SE = .061$, $p < .001$) and *maintain* ($M = 2.27$, $SE = 0.05$, $p < .001$), and *decrease* showed lower ratings of arousal than *maintain* ($p < .001$). The GLM also revealed a main effect of valence $F(1,61) = 140.97$, $p < .001$. Unpleasant photos ($M = 2.61$, $SE = .06$) were rated as more arousing than pleasant photos ($M = 1.87$, $SE = .05$, $p < .001$). Lastly, there was a significant interaction between instruction and valence, $F(2,60) = 7.41$, $p < .05$. In response to negative pictures, *increase* reappraisals ($M = 2.74$, $SE = .07$) led to greater ratings of arousal than *decrease* reappraisals ($M = 2.38$, $SE = .08$, $p < .001$); *decrease* reappraisals led to lower ratings of arousal than *maintain* ($M = 2.70$, $SE = .07$, $p < .001$); there was no significance *increase* and *maintain* reappraisals ($p = .34$) In response to positive pictures, *increase* reappraisals ($M = 2.10$; $SE = .06$) led to greater ratings of arousal than *decrease* ($M = 1.66$; $SE = .05$; $p < .001$) and *maintain* ($M = 1.84$; $SE = 0.05$; $p < .001$). Additionally, *decrease* reappraisals led to lower ratings of arousal than *maintain*, $p < .001$.

Self-reported ratings of valence were also used to determine whether participants successfully engaged in cognitive reappraisal. A multivariate GLM revealed a significant effect for reappraisal instruction $F(2,60) = 6.5$, $p < .005$, valence $F(1,61) = 2062.68$, $p < 0.001$, and, importantly, a significant interaction between the two $F(2,60) = 9.74$, $p < .001$. With regards to reappraisal instruction, a post-hoc test revealed that participants rated trials with *increase* ($M = 2.13$, $SE = .01$) reappraisals as being less unpleasant than trials with *maintain* ($M = 2.17$, $SE = .01$, $p < .005$) and *decrease* ($M = 2.17$, $SE = .01$, $p < .005$) instructions. There was no significant difference between *decrease* reappraisals and

maintain with regards to ratings of valence, $p = .63$. As expected, unpleasant pictures ($M = 2.85$, $SE = .01$) were rated as more unpleasant than pleasant pictures ($M = 1.47$, $SE = .02$, $p < .001$). The interaction between valence and regulation instruction revealed that for trials with unpleasant pictures, the *decrease* instruction ($M = 2.81$, $SE = .02$) resulted in lower ratings of unpleasantness in comparison to *maintain* ($M = 2.87$, $SE = .01$, $p = .001$) and *increase* ($M = 2.86$, $SE = .01$, $p < .05$). There was no significant difference between *increase* reappraisals and maintain, $p = .41$. Within trials with pleasant pictures, the *decrease* instruction ($M = 1.54$, $SE = .03$) produced ratings that were rated as more unpleasant than trials with the *maintain* ($M = 1.46$, $SE = .02$, $p < .05$) and *increase* instructions ($M = 1.40$, $SE = .02$, $p < .001$), and *increase* trials were rated as less unpleasant than those in *maintain* trials, $p < .01$.

These findings suggest that, for the most part, participants were able to successfully use cognitive reappraisal throughout the different conditions.

Hypothesis Testing. We hypothesized that the *increase* and *decrease* reappraisals would result in significantly greater pupil dilation in comparison to *maintain*. Additionally, we hypothesized that the *increase* instruction would result in greater pupil dilation than the *decrease* instruction. Mean pupil diameter for each condition and time point is shown in Figure 2. A multivariate GLM revealed a significant interaction between time and cognitive reappraisal instruction, $F(20,38) = 2.09$, $p = .02$. Pairwise comparisons revealed that reappraisal instruction approached significance between the 1s – 3s time interval (roughly corresponding to the instruction slide) such that pupil dilation for *maintain* was greater than that of *decrease*. No significant main effects were found for regulation effects or valence. Additionally, there was a significant interaction between valence and time

$F(10,48) = 4.09$, $p < .001$. Follow up tests revealed that negative trials resulted in greater pupil dilation than positive trials roughly during the presentation of these pictures. There was no main effect or regulation instruction ($F(2,56) = 1.4$, $p = .25$) or valence ($F(1,57) = 1.87$, $p = .17$), or any significant interaction between the two ($F(2,56) = 0.21$, $p = .80$). See Figure 2 for a visual of these results.

Luminance. Given the unexpected pupil dilation findings of valence, we decided to test the luminance of the pictures to see if they differed between pleasant, unpleasant, and neutral pictures. As pupils respond to light, we considered whether the valence findings may have been related to differences in luminance. Using the histogram feature on GNU Image Manipulation Program, we averaged luminance levels for unpleasant, pleasant, and neutral photos and a multivariate GLM found a main effect of valence, F (2, 73) = 7.92, $p < .001$. A post-hoc test (Fisher's LSD) showed that unpleasant pictures ($M = 106.65$, $SE = 4.67$) were significantly less bright than either pleasant ($M = 133.65$, $SE = 5.36$, $p < .001$) or neutral pictures ($M = 127.59$, $SE = 5.60$, $p = .005$). These results indicate that the difference in luminance influenced the interaction between valence and time, such that unpleasant pictures resulted in greater pupil dilation than pleasant pictures because unpleasant photos were not as bright as pleasant photos.

Discussion

Summary of Results

According to self-reports, participants rated images as more arousing when they were asked to increase their emotional response and less arousing when asked to decrease their emotional response. Additionally, the findings revealed a significant interaction

between valence and arousal for ratings of unpleasantness, such that when participants were asked to decrease their response to an unpleasant/pleasant picture, they rated the picture as less unpleasant/pleasant respectively. The same interaction was also found with ratings of arousal. While these ratings suggest that participants reported that they successfully reappraised their responses to the emotional stimuli, there was no significant difference between any of the cognitive reappraisal strategies with regards to pupil size. Although the results were not significant, the data did approach significance roughly around the time of the instruction slide in a trend that revealed that the *maintain* instruction led to greater pupil dilation in comparison to the *decrease* instruction.

Why the Hypotheses May Not Have Been Supported

Although follow up analyses suggested that the participants showed greater pupil dilation in the *maintain* instruction than in the *decrease* instruction, the data were ultimately not significant and did not fall in line with previous studies that examined pupil dilation during cognitive reappraisal, such as Urry et al. (2006, 2009). While I expected the *increase* and *decrease* reappraisals to result in greater pupil dilation than the *maintain* instruction, a few studies seem to suggest that simply processing emotional stimuli requires cognitive resources (Pessoa, Kastner, & Ungerleider, 2002; Okon-Singer, Tzelgov, & Henik, 2007). In a study conducted by Smith Erthal, Oliveira, Mocaiber, Pereira, Machado-Pinheiro, Volchan and Pessoa (2005), participants were instructed to indicate the orientation of a bar as task-irrelevant, emotional stimuli were presented alongside the bars. Researchers manipulated the difficulty of the task and found that reaction times (RT) were slower with the easier task and faster with the more difficult task. Smith Erthal et al. took these results to mean that the increase in cognitive demand left no resources for the

emotional stimuli to be processed and thus RT were faster (2005). If this is the case, it is possible that the data for this study were similar not because the regulation instructions were not cognitively demanding, but because they were all cognitively demanding to a similar extent.

Another interesting aspect to consider is the use of the word "maintain" as a regulation condition and how participants respond to this instruction as opposed to other commonly used instructions, such as "look," "watch," or "view." Schaefer, Jackson, Davidson, Aguirre, and Kimberg (2002) tested the effects of the instructions *maintain* and *view* on amygdalar activity in response to highly arousing and unpleasant images using fMRI. When participants were instructed to *maintain* their response, they were asked to "'maintain the initial emotional response produced by the picture throughout the picture presentation" while *view* instructions instructed participants to "allow the initial emotional response to rise and fall naturally without trying to regulate the emotion produced by the picture" (2002). Self-reports indicated that participants felt more negative on maintain-negative than view-negative trials. While there was no significant effect of instruction, a significant interaction between regulation and valence revealed greater amygdalar activation for the maintain-negative condition than the view-negative conditions. Although these results are not directly related to cognitive demand, the difference in self-reports and amygdalar activity may suggest that instructions like *maintain* and *view* might lead participants to process the stimuli differently, thus engaging in slightly different emotion regulation strategies.

Strengths and Limitations

One strength of this study was that participants were reportedly able to successfully engage in the different emotion regulation goals. As demonstrated in the ratings of arousal and valence, it appears that the regulation instructions were detailed enough that participants were able to successfully reappraise their emotional responses to the images. Another strength was the balance of valence and regulation instructions in the design. Many studies in the emotion regulation literature tend to focus on negative stimuli, whereas this study sought to provide a more complete picture by examining cognitive reappraisal with regards to both positive and negative stimuli. In this way, the study better reflected our day-to-day emotion regulation processes with positive and negative experiences.

However, as the design of this experiment was not well-constructed to accurately capture pupil dilation as a measure of cognitive demand. The study was originally designed as an ERP study, meaning that the effects of stimulus brightness and presentation duration were not taken into consideration with pupil dilation in mind. Specifically, this experiment was designed to record the late positive potential amplitude, which appears 250 to 300ms after stimulus presentation (Hajcak & Nieuwenhuis, 2006). For a design created to capture this amplitude, a 2s stimulus presentation is more than enough time. However, pupil dilation requires a bit more time to reflect the cognitive demand of reappraisal. In Urry et al. (2009), participants first viewed the stimulus for 4s after which they were instructed to reappraise their emotional response and given 8s to do so. Pupil dilation results were only significant 2s after instruction onset. So not only were participants given time to experience the stimulus beforehand, but they were also given a greater amount of time to

carry out reappraisal. While certain responses, like LPP, may show differences early on, pupil dilation requires more time to reflect the physiological changes aroused by the task.

Another limitation of this study was the design of the *maintain pleasant* and *maintain unpleasant* blocks. Unlike the other blocks, these two blocks did not include neutral images and thus did not match the structure of the other blocks. By excluding the neutral images, participants were constantly presented with emotional stimuli, thus not allowing for a break from the emotional information. The inconsistency in structure between these blocks means that they cannot be directly compared in analysis given that they may have elicited different responses due to the design of the study and not the independent variables.

With regards to the stimuli, there were differences in luminance and IAPS ratings of arousal that may have influenced pupil dilation. After comparing the average luminance of the images, results showed that negative images were less bright than neutral and positive images. Additionally, the IAPS ratings showed a significant difference in ratings of arousal, such that negative images were rated as more arousing than positive images. Since pupil dilation is responsive to changes in light, as well as arousal (Bradley, Miccoli, Escrig, & Lang, 2008), these differences make it difficult to tell whether the changes in pupil dilation in this study were a result of cognitive demand, changes in light, or differences in arousal. In order to examine pupil dilation as an index of cognitive demand, both luminance and arousal should be standardized across the stimuli so that they do not influence the results.

Theoretical and Practical Implications

Understanding the implications of cognitive demand and cognitive reappraisal could serve a very important role in understanding how different people reappraise in the real

world. For instance, differences in cognitive demand within cognitive reappraisal might explain why certain populations, such as the elderly, may not be able to reappraise their emotional responses as well as young adults due to fewer cognitive resources (Salthouse, 2004). In a study by Shiota and Levenson (2009), participants in their 20s, 40s, and 60s were instructed to decrease their emotional responses to a film clip and the findings showed that the oldest cohort were least successful in decreasing their emotional responses. However, this same group was the most successful in positively reappraising their emotional experiences. These results are consistent with studies that have suggested that older adults focus more on positive information than negative information through emotion regulation strategies, such as situation selection and attentional deployment, but find it difficult to engage in decrease reappraisals due to fewer cognitive resources. (Urry & Gross, 2010) These results potentially indicate that greater cognitive resources could lead to more successful execution of decrease reappraisals, as well as other goals. However, whether this is true for all cognitive reappraisal goals or just certain reappraisals needs to be determined by more research on cognitive demand within cognitive reappraisal.

Future Research

Given the null results of this study, future research might improve upon this experiment to design a study more suited to examine cognitive demand. For instance, extending the stimulus presentation beyond two seconds might allow for a physiological index of cognitive demand to yield significant results, similarly to the designs of Urry et al. (2006, 2009) that also used pupil dilation to measure cognitive demand. Another possibility might be to examine differences in cognitive demand of multiple passive-viewing instructions, for instance, “maintain,” “view,” and “look,” to see if these subtleties

might actually affect how people respond to a stimulus. Other research might examine how individuals with varying levels of cognitive resources freely choose to reappraise an emotional situation and determine whether the cognitive demand of reappraisal plays a role in their selection of reappraisal goals.

Conclusions

Although we hypothesized that reappraisal goals would result in greater pupil dilation than the passive viewing of emotional stimuli and that increase reappraisals would also result in greater pupil dilation than decrease reappraisals, the findings indicated that maintaining one's emotional response is more cognitively demanding than the emotion regulation strategy. However, this study did not fall in line with previous research, suggesting that these findings were more the result of the present study's limitations. Nonetheless, understanding the cognitive demands associated with cognitive reappraisal is still an area that deserves more research.

Given that emotion regulation helps us cope with the ups and downs of daily life, it is important for us to understand how to best use it in different situations. For instance, it may be that it is more difficult to decrease nervousness during an exam or more easy to increase positivity before taking it. Understanding how cognitive demand may play a factor in our selection of emotion regulation strategies is just one of the ways that we can learn to make cognitive reappraisal work best for us.

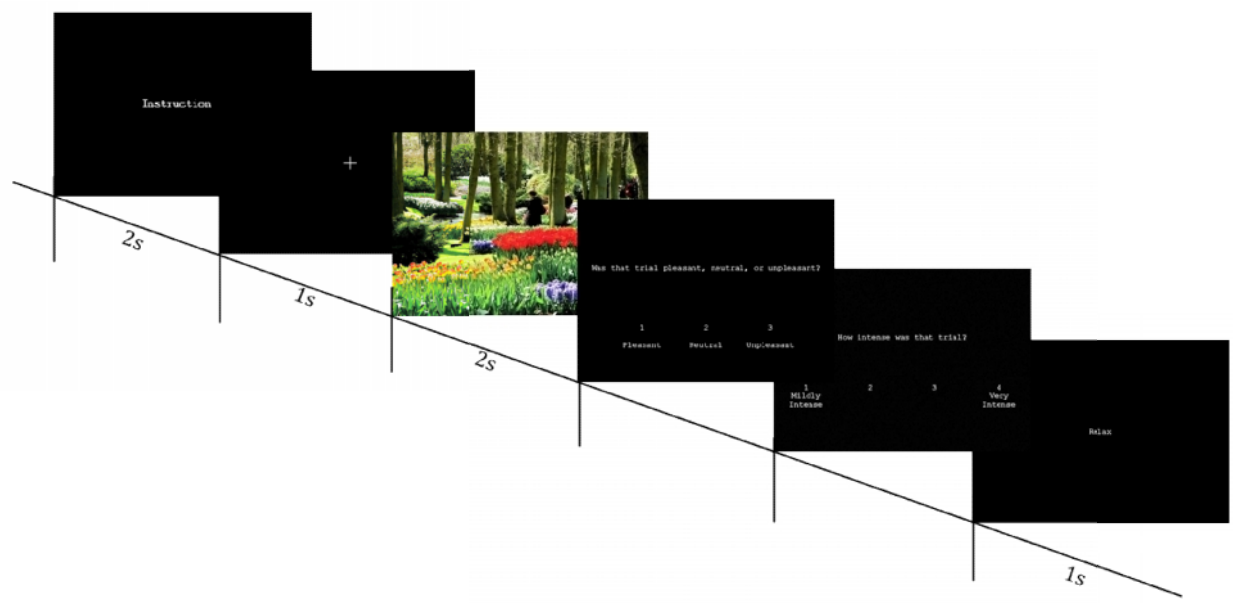

Figure 1. Trial structure. During the experiment, the "Instruction" slide shown here either instructed participants to *Increase, Decrease,* or *Maintain* their emotional response to the picture. Rating slides appeared on-screen for an indefinite amount of time until participants indicated their responses on the keyboard.

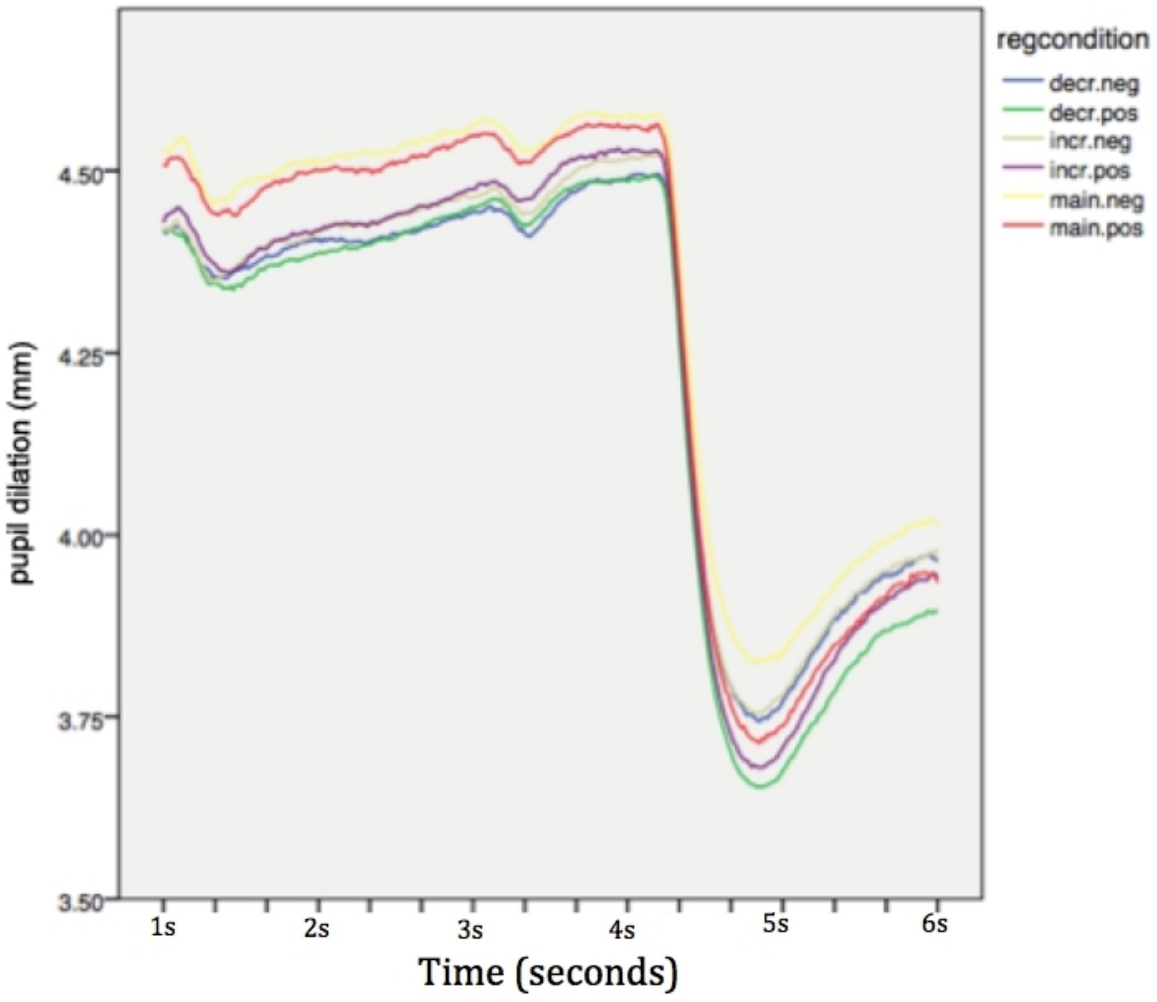

Figure 2. Pupil dilation (mm) across the six blocks (instruction x valence) mapped temporally. 1s represents the Instruction portion of the trial through 6s, which represents the end of picture presentation.

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Appendix

(Initial instructions describing how to *decrease*, *increase*, and *maintain*)

"Shortly, you will be presented with images. Each image will appear on the screen for 2 seconds. Please view each image carefully. Before each set of images you will see a slide that will tell you to either MAINTAIN, DECREASE, OR INCREASE the emotions you feel in response to the picture.

Here is what we mean by INCREASE, DECREASE, and MAINTAIN:

On some trials you will be asked to INCREASE your emotional response to a set of pictures. Before each picture, the world INCREASE will be presented on the screen to remind you what to do. By increase we mean we would like you to increase the intensity of the motion you feel in response to the picture. Try to feel the emotion more strongly. For example, think of how someone who likes scary movies enters a movie theatre to see a scary movie. So, when you see the world INCREASE, prepare yourself to increase the intensity of whatever emotion you feel in response to the picture. Prepare yourself to feel the emotion more strongly.

On other trials, you will be asked to DECREASE your emotional response to a set of pictures. Before each picture, the word DECREASE will be presented on the screen to remind you what do. By decrease we mean that we would like you to reduce the intensity you feel in response to the picture. Try to feel the emotion less strongly. For example, think of how a doctor enters an emergency room. The doctor knows that he/she will be entering a negative environment and prepares him/herself to deal with that by decreasing the negative emotions he/she might feel when he/she enters the room. So, when you see the word DECREASE, prepare yourself to decrease the intensity of whatever emotion you

might feel in response to the picture. Prepare yourself to feel the emotion less strongly. Decreasing an emotion is not equivalent to replacing that emotion with a different one. Do no generate thoughts and images that are completely unrelated to the presented stimulus in order to produce a different emotion to compete with or replace your initial emotional response to the picture. For example, if you are asked to decrease the fear you feel in response to a picture of a poisonous snake, do not think of something unrelated that generates a positive emotion, e.g., the end of finals week and beginning of winter holiday! However, feel free to focus on a positive aspect of the picture or on a possible positive outcome of the situation in the picture. For example, you can imagine that the poisonous snake is about to be killed, which may help you decrease the fear you may feel in response to the picture.

When asked to MAINTAIN, please view each image carefully and simply react as you would normally."