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The role of reappraisal success in emotional and memory outcomes

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Abstract

Cognitive reappraisal is an emotion regulation strategy that involves reinterpreting the meaning of an event or its outcome to change its emotional trajectory. In this study, we examined how cognitive reappraisal affects both emotional experience and memory outcomes. We also examined whether these outcomes are modulated by participants' self-reported success at generating reappraisals. To do this, we asked participants to use situation-focused reappraisals to decrease their emotional response to some negative images and to passively view other negative images while facial EMG was recorded. After each trial, participants rated the image's emotional valence and arousal. During reappraisal trials, participants also self-reported their success in generating a reappraisal. One week later, memory was assessed with a surprise free recall test followed by a recognition test. Compared to images that were passively viewed, participants (N = 42) rated the successfully reappraised images as lower in arousal and less negative in valence. Meanwhile, there was an emotional cost associated with failures to generate reappraisals; participants rated these images as higher in arousal and more negative in valence. No similar effects emerged for the EMG ratings. In contrast to these emotional outcomes, a different pattern emerged for the memory outcomes. Instructions to reappraise led to enhanced recall and recognition and to greater memory confidence regardless of whether or not participants successfully generated the reappraisals. Taken together, these results suggest that trying, but failing, to generate a situation-focused cognitive reappraisal may be detrimental. In these situations, people feel worse but remember the situation well.

Key words: emotion regulation, cognitive reappraisal, memory, recall, recognition

The role of reappraisal success in emotional and memory outcomes

Emotions are often beneficial. They allow us to coordinate adaptive responses to a variety of challenges and opportunities (Levenson, 1994; Tooby & Cosmides, 1990). They can also lead to memory benefits, such that emotional information is typically remembered better than neutral information (Kensinger & Corkin, 2003; LaBar & Phelps, 1998). However, sometimes emotions can be detrimental. They can occur at the wrong time, last too long, or be too great in intensity. When this happens, we often *regulate* our emotional responses to align with our current goals (Gross, 1998a). In the current study, we examined how one particular emotion regulation strategy **–** namely *cognitive reappraisal* -- affects our emotional experiences and our memory for the emotion-eliciting event. We also tested whether these emotional and memory outcomes are modulated by participants' success in implementing this emotion regulation strategy.

The effects of cognitive reappraisal on the experience of emotion

Emotion regulation encompasses all the strategies we use to influence our emotions. This includes which emotions we have, how intensely they are experienced, and how they are expressed (Gross, 1998a, 2015). Although we have a broad range of emotion regulation strategies at our disposal (see Richards & Gross, 2000), the focus of this study is on the emotion regulation strategy of *cognitive reappraisal.* This involves reinterpreting the meaning of an event or its outcome to change its emotional trajectory (Hayes, Morey, Petty, Seth, Smoski, & McCarthy, 2010; Richards & Gross, 2000). For example, in an effort to increase performance, an athlete at a competitive event may tell herself that the event is not threatening but a challenge and opportunity to show case her abilities. As another example, after being cut off in traffic, you may tell yourself that it was because the other driver was lost or had an emergency. When successful, cognitive reappraisal should change how people feel about the situation (e.g., an athlete feeling relaxed or in the zone; Richards & Gross, 2000). Consistent with this, participants who self-report habitually using cognitive reappraisal also report experiencing and expressing more positive emotions and fewer negative emotions and also report fewer depressive episodes (Gross & John, 2003). Likewise, in lab studies, participants who are instructed to cognitively reappraise negative situations have better emotional outcomes than those who are not given this emotion regulation instruction (e.g., Gross, 2002; Ochsner, Bunge, Gross, & Gabrieli, 2002). Results of a recent meta-analysis confirm that the emotional benefit associated with cognitive reappraisal is reliable, with a small-to-medium effect size (Webb, Miles, & Sheeran, 2012).

The effects of cognitive reappraisal on memory outcomes

In addition to improving emotional outcomes, Richards & Gross (2000, Experiment 2) reported that cognitive reappraisal also enhances memory for the emotion-eliciting stimulus. In this study, participants were asked to reappraise their emotional response, inhibit any outward displays of emotions (i.e., use the emotion regulation strategy of suppression), or simply watch negative pictures. Later, they were asked to recognize the images they had seen earlier from amongst similar distractors. The results showed that recognition hit rates were higher when participants cognitively reappraised the pictures compared to when they suppressed their outward emotional responses or simply watched the pictures. These results have since been extended to naturalistic settings (Richards, Butler, & Gross, 2003), to incidental recognition tests given at longer delays (Kim & Hamann, 2012; Hayes et al., 2010), and to free recall tests (Willroth & Hilimire, 2016; see also Dillon, Ritchey, Johnson, & LaBar, 2007).

However, attempts to replicate these findings have not always been successful. Some studies have found that cognitive reappraisal only enhances memory for certain participant groups (e.g., men; Kim & Hamann, 2012), or only for certain types or aspects of the to-be-remembered stimuli (e.g., only high arousal images or only the background details; Richard & Gross, 2000 and Steinberger, Payne, & Kensinger, 2011, respectively), or only on certain types of memory test (e.g., occurring for recognition but not for recall; Kim & Hamann, 2012). Furthermore, other studies have failed to replicate this effect entirely (Ahn et al., 2015; Erk, Kalckreuth, & Walter, 2010), or have even found the opposite pattern (Knight & Ponzio, 2013).

One explanation for the mixed findings is that studies have differed in how they have defined reappraisal. A recent meta-analysis by Webb, Miles, and Sheeran (2012) identified four different types of reappraisal instructions that have been used in prior studies. These variations in reappraisal instructions affect not only the magnitudes of emotional benefits (Webb, et al., 2012), but also their associated memory outcomes. For example, in a study by Willroth and Hillmire (2015) participants were shown emotional pictures and were randomly assigned to one of three viewing conditions. In the situation-focused reappraisal condition, participants were instructed to "*reinterpret the emotions, actions, and outcomes of individuals as they are depicted in their situational context. In other words, imagine the picture events are getting better*". In contrast, in the self-focused reappraisal condition participants were instructed to "*increase your sense of objective distance, viewing the pictured events from a detached, third-person perspective*". Lastly, in the view condition participants were instructed to let their emotions unfold naturally. Later, all participants completed a surprise recall task, in which they were asked to write down descriptions of each of the pictures they had previously seen. The findings showed that only situation-focused reappraisals enhanced recall. There was no difference in the memory outcomes between self-focused reappraisal and view conditions.

The notion that situation-focused reappraisals should improve memory is not surprising from a memory perspective. Situation-focused reappraisals involve changing the meaning of the emotion-eliciting stimulus or its outcome, using the details and context of the broader situation. This encourages effortful engagement and significant stimulus elaboration in a way that self-focused reappraisal and viewing the picture do not. A large body of research has shown that this kind of elaborative processing for meaning increases later memory performance (Craik, 2002, Craik & Tulving, 1975). These findings are typically explained through the lens of Craik and Lockhart's (1972) levels of processing framework. According to this view, information processed "deeply" for meaning is remembered better than information processed "shallowly" for perceptual features. This finding is well-established; deep elaborative processing has led to enhanced memory in hundreds of studies (for reviews and extensions of this theory, see Craik, 2002; Eich, 1985).

The role of reappraisal success in modulating emotion and memory outcomes: An unanswered question

Thus, research to date has suggested that reappraisals – at least when they are situation-focused – often reduce negative emotions and enhance memory. However, an unanswered question is how these presumed emotional and memory outcomes are affected by perceived *success* at implementing this emotion regulation strategy. This is an important question because generating a situation-focused reappraisal is not always possible. For example, Opitz and colleagues (in preparation) found that as the arousal levels of negative pictures increased, people were less likely to successfully generate a situation-focused reappraisal within the allotted time. Similarly, Suri and colleagues (2017) demonstrated that participant's success in generating reappraisals depended on the pictures' affordances – i.e., the opportunities for re-interpretations that are available within the stimulus. For example, a picture of a car crash may offer several affordances for reappraisal. Participants could tell themselves that no one was seriously injured or that help was on the way. However, an image of a dead baby offers very few affordances; it is extremely difficult (if not impossible) to think of this situation in a way that reduces negative affect. Consistent with this, people tend to be more successful at generating reappraisals when affordances are high (Suri, Sheppes, Young, Abraham, McRae, & Gross, 2017). Variations in reappraisal success occur not only across situations, but also across individuals (e.g., Troy, Wilhelm, Shallcross, & Mauss, 2010). For example, reappraisal success appears to be reduced in people with depression (Johnstone, van Reekum, Urry, Kalin, & Davidson, 2007) and may depend upon the specific tactics selected by participants (McRae, Ciesielski, & Gross, 2012). These studies highlight the variability that exists in individuals' ability to successfully generate reappraisals (see also McRae, 2013).

Presumably, attempting to implement an emotion regulation strategy will not improve emotional outcomes if it is unsuccessful. Trying, but failing, to think of ways to feel better about a negative situation should not make you feel better. In fact, it may actually make you feel worse. However, it is less clear whether self-reported success at generating situation-focused reappraisals modulates its presumed memory enhancement. There are four potential outcomes. One possibility is that success is a prerequisite to produce a memory enhancement; if people self-report not being able to generate a reappraisal this could indicate that they did not engage in elaborative deep processing, and thus there should be no memorial benefit.

A second possibility is that attempting to generate a situation-focused reappraisal leads to memory enhancements even when people cannot successfully implement this emotion regulation strategy. This is because attempting to use this strategy still requires people to engage with, and elaborate upon, the emotion-eliciting situation. For instance, imagine that you have been insulted by your coworker. You could attempt to reappraise this situation by telling yourself that she must be having a bad day. However, if you know that she just experienced a happy life circumstance and has actually been incredibly pleasant with your other coworkers, this reappraisal will be deemed ineffective and may be dismissed. In this situation you may have failed to successfully generate an effective reappraisal, but the act of elaborating upon the situation and attempting to generating reappraisals should still lead it to be well-remembered (as compared to other similarly emotional events that you did not try to reappraise).

A third possibility is that both success and failure may lead to superior memory compared to just viewing a stimulus, but the magnitude of these effects is greater when people are successful. When affordances to generate a reappraisal are low, people may begin to elaborate upon the situation in order to generate a reappraisal. However, when the initial attempt is unsuccessful they may quickly move on to an alternate regulation strategy, such as distraction. Although the initial attempt to elaborate upon the situation may lead to a memory enhancement it may be smaller in magnitude than the one associated with a successful reappraisal.

A final possibility is that attempting to generate a situation-focused reappraisal always enhances memory, but the magnitude of this effect is greater when people fail. Support for this comes from a study by Kim and Hamann (2011). In this study, participants were sometimes instructed to decrease their emotions to negative stimuli using reappraisal. As expected, reappraisal resulted in lowered physiological responses and higher subsequent memory. However, changes in facial corrugator electromyography responses (which is an index of stimulus valence; Bradley & Lang, 2007) predicted recognition memory. When participants successfully modulated their facial corrugator response, they showed a smaller enhancement in recognition memory. This suggests that participants who were less successful at modifying their emotions had larger memory benefits. This may be because participants increased their attention to the stimuli in an effort to analyze and manipulate the significance of the emotional stimuli. Alternately, this may reflect the fact that these stimuli remained high in emotional arousal (which in itself confers memory benefits; e.g., Bradley, Greenwald, Petry, & Lang, 1992) while also being processed in a more elaborative manner.

In summary, many previous studies suggest that cognitive reappraisal – at least when it is situation-focused – has beneficial effects on both emotional and memory outcomes. However, an open question is whether these outcomes depend upon participants' self-reported success in using this emotion regulation strategy. Although we predict that success is a necessary prerequisite for enhancing emotional well-being, it is unclear whether self-reported success in implementing this strategy will affect memory for the emotion-eliciting stimulus. The overarching aim of the current study was to test this question. In doing so, we included four different memory measures. Our hypotheses center on memory strength for the emotion-eliciting stimulus. In the current study, this is reflected in free recall accuracy, recognition hit rates, and recognition confidence (which is a more graded measure of recognition memory strength). However, to gain a more complete understanding of how emotion regulation affects memory outcomes, as an exploratory measure we also assessed source memory – i.e., memory for the regulation strategy that was used for each of the recognized items.

Method

Participants

This two-session study initially included 52 healthy English-speaking adults. However, 5 participants failed to return for the second study session. Thus, our final sample was 47 participants (40 women, 7 men) from San Francisco State University (SFSU), with 33% identifying themselves as Caucasian, 29% as Asian, 19% as Hispanic, 6% as African-American, and 13% who declined to state. Participants were on average 23.8 years old (*SD* = 5.10; range = 18-40). All study procedures were approved by the Institutional Review Board at SFSU. A power analysis in GPower 3.1 suggested that this sample would provide over 80% power to observe small-to-medium differences (effect sizes greater than *f* = .20) between the images that were viewed, successfully reappraised, and unsuccessfully reappraised.

Stimulus materials

A total of 160 negative images were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). The negative images were partitioned into 4 sets of images that were matched for valence, arousal, and general content.[1] For each participant, two sets of images were used during the cognitive reappraisal task (one set with instructions to view and one set with instructions to use situation-focused reappraisals; see Procedure). The remaining two sets of images were presented as new items during the recognition memory test. Across participants the assignment of image sets to each of these categories was counterbalanced.

Procedure

Participants completed two experimental sessions, spaced one week apart. Participants began session one by giving written informed consent and completing a series of individual

[1] Set 1: IAPS numbers 1110, 1271, 1304, 1310, 2053, 2120, 2278, 2455, 2661, 2692, 2717, 2800, 2811, 3059, 3061, 3102, 3170, 3180, 3215, 3225, 3266, 3301, 3500, 4664.2, 5973, 6212, 6213, 6315, 6415, 6821, 6838, 8485, 9163, 9184, 9413, 9427, 9620, 9622, 9630, 9810. Set 2: IAPS numbers 1033, 1050, 1201, 1202, 1301, 1931, 1932, 2095, 2276, 2345.1, 2457, 2691, 2703, 2751, 3010, 3022, 3030, 3053, 3160, 3185, 3212, 3220, 3250, 3261, 3550, 6022, 6211, 6230, 6244, 6312, 6530, 8230, 9075, 9187, 9250, 9321, 9400, 9500, 9902, 9921. Set 3: IAPS numbers 1052, 1111, 1200, 1274, 1302, 1726, 2110, 2205, 2683, 2688, 2700, 2799, 2981, 3051, 3060, 3100, 3101, 3168, 3190, 3213, 3230, 3350, 3530, 6200, 6220, 6250.1, 6370, 6520, 6830, 6831, 9183, 9185, 9405, 9424, 9435, 9600, 9800, 9901, 9908, 9941. Set 4: IAPS numbers 1040, 1070, 1090, 1220, 1280, 1300, 1321, 1930, 2141, 2456, 2694, 2710, 2730, 2900, 3015, 3062, 3063, 3110, 3181, 3195, 3216, 3300, 3400, 5961, 6021, 6210, 6313, 6510, 6563, 6825, 9050, 9160, 9254, 9326, 9410, 9428, 9491, 9623, 9904, 9905.

differences questionnaires (see Supplemental Materials A). They were then introduced to our cognitive reappraisal task. Participants were told that they would be shown negative images under one of two viewing conditions: View or Decrease. Instructions for the View trials were adapted from previous studies (Dillon et al., 2007; Knight & Ponzio, 2013). Participants were told that during these trials they should "*look at the picture and allow it to affect you, even though it may generate negative emotions. Please do not distract yourself or look away or attempt to change the meaning of the picture*". In contrast, during the Decrease trials we asked participants to use situation-focused reappraisals using instructions from Webb, Miles, and Sheeran (2012). Here, participants were instructed that "*while looking at the picture, try your best to feel less negative about it. To do this, we want you to reinterpret the meaning of picture by using the context of the picture to feel less negative*". We required the reappraisals to be situation-focused. Additional instructions to participants explained that participants could reinterpret either the current circumstances or the future consequences of the depicted situation. However, reinterpretations could not be accomplished by thinking that the images were fake or by attempting to distance themselves from the image by taking a third person perspective or by simply trying to generate the opposite (positive) emotion. For all pictures (during both the View and Decrease trials), participants were instructed to stay focused on the picture strategy and were asked not to look away or distract themselves by thinking of other things.

To ensure that participants understood these instructions, all participants next completed a training phase. Participants were shown examples of how to appropriately respond to images during the View and Decrease conditions. They were then shown new images and were asked to generate aloud situation-focused reappraisals. In cases where participants generated an inappropriate reappraisal (e.g., telling themselves the image was from a television show) or used an inappropriate strategy (e.g., thinking about something else), the experimenter provided corrective feedback. In cases where the participant was unable to generate a reappraisal, the experimenter provided an additional example. All participants were able to generate at least one situation-focused reappraisal during this training phase.

After completing the training phase, participants began the cognitive reappraisal task (see Figure 1). This task consisted of 8 practice trials followed by 80 critical trials. Each trial began with either the cue word View (40 critical trials) or Decrease (40 critical trials) presented above a jittered (2 to 3s) fixation cross. Following the cue, a negative image was presented for 6s and was immediately replaced with blank screen for 6s, during which time the participants were asked to continue using the assigned picture strategy. During the Decrease trials, this was then followed by a self-report measure of reappraisal success. Participants rated how difficult it had been to generate a reappraisal for the image (i.e., 1 = easy, 2 = hard, 3 = unsuccessful). They were instructed to use the "unsuccessful" option when they were unable to reinterpret the meaning of the picture in a way that would reduce its negativity within the allotted time. Then, participants completed a self-paced arousal (1 = very calm to 6 = very excited) and negative valence (1 = neutral/not unpleasant to 6 = very unpleasant) rating of the image. The View trials were identical to the Decrease trials with one exception: they did not include a rating of reappraisal difficulty. All images during this task were negative in valence; there were no neutral or positive images. The negative images were presented in a random order and cues to Decrease or View were intermixed. Participants were unaware that their memory for the images would be assessed during session two.

During the cognitive reappraisal task we also collected a measure of emotional expression using facial electromyography (EMG). Prior research has shown that corrugator facial muscle activation increases in response to aversive stimuli (e.g., Cacioppo, Petty, Losch, & Kim, 1986; Lang, 1995). However, this activation is reduced when participants are instructed to downregulate their emotions using cognitive reappraisal (Ray, McRae, Ochsner, & Gross, 2010). In the current study, corrugator electromyography (EMG) was continuously acquired using two 4-mm electrodes (Biopac Inc., Santa Barbara, CA) placed above the left eyebrow, with a ground electrode placed on the center of the forehead. The EMG data was acquired with an EMG MP 150 amplifier (Biopac Inc., Santa Barbara, CA) using a gain of 5,000 with a sampling rate of 1,000khz. All impedance levels were maintained below 20kΩ (Cacioppo, Tassinary, & Fridlund, 1990). Offline, a bandpass filter (20 Hz to 500 Hz; 60 Hz notch) and root mean square (100ms window) transformation was applied to the signal.

One week later participants returned for session two, which began with a surprise free recall memory test. Participants were given a maximum of 15 minutes to describe as many images as possible from the cognitive reappraisal task that occurred during session one, in as much detail as possible (regardless of the order they were presented). Recall was self-paced but completion times were not recorded. Recall was subsequently scored by two coders blind to the viewing conditions. An image was scored as correctly recalled if the participant provided a description that the coder determined to clearly match one specific picture from the cognitive reappraisal task. The recalled images were then classified according to whether or not they had been associated with Decrease or View instructions. The majority of unscored responses were descriptions that were too general to be matched to a specific picture. Agreement between the two coders was high (94%) and ratings from the primary coder were used in analyses.

Immediately following the free recall task, participants were given an old-new recognition test. Participants were shown the 80 images from the session one cognitive reappraisal task intermixed with 80 new images. Pilot testing revealed ceiling effects in performance on this assessment. This was not surprising since people are known to have remarkably good memory for photographs (for a review, see Madigan, 2014). To mitigate this, all images for the recognition test during the current study were shown to participants in black and white since this context change has been shown to reduce recognition accuracy (Torralba, Fergus, & Freeman, 2008). After making the old-new recognition decision, confidence ratings (1 = no confidence to 6 = complete confidence) were collected. When participants responded that an image was old, they were also asked to make a source memory decision about how it had been presented during session one; participants selected whether they had been instructed to Decrease or View that particular image. Across participants, the image sets were counterbalanced to appear equally often as part of the cognitive reappraisal task versus a "new" item on the surprise recognition memory test. Because of the way the picture sets were created this also meant that the old and new images (all negative in valence) were matched on arousal, valence, and content (see Stimulus materials). After completion of the memory tasks, participants completed additional cognitive tasks. Although these will not be discussed further here, additional details about the individual difference measures included in this study and their relationship to cognitive reappraisal abilities can be found in Supplemental Materials A.

Results

The goals of this study were to determine whether the emotional and memory outcomes associated with cognitive reappraisal depend upon participants' self-reported success in implementing this emotion regulation strategy. In the following analyses, we first examined whether the experimental instructions during the cognitive reappraisal task affected participants' emotional responses to, and memory for, the images. We then examined whether these emotional and memory outcomes varied as a function of each participants' trial-by-trial success in generating the cognitive reappraisals. We operationalized success based upon participants' self-reports. As noted in the Procedure, during the Decrease trials (where participants were tasked with generating a cognitive reappraisal), participants also rated how difficult it had been to implement the instructions (1 = easy, 2 = hard, 3 = unsuccessful). In subsequent analyses, self-reported "easy" and "hard" responses were collapsed into "success" trials. Overall, participants succeeded in generating cognitive reappraisals ($M = 30.74$, $SD = 5.67$) on more trials than they failed ($M = 9.24$, $SD = 5.21$). However, there was also considerable individual variability with success rates ranging from 37% to 100% of the trials. Because we were interested in the emotional and memorial consequences of succeeding versus failing to generate a cognitive reappraisal, in the following analyses we limited our sample to the 42 participants who failed to generate a reappraisal on more than one trial.

Emotion outcomes as a function of cognitive reappraisal task instructions

We first examined whether instructions to reappraise negative images affected their perceived arousal and valence (regardless of whether participants rated themselves as successful or not at implementing those instructions). For the arousal scale, higher scores reflect greater emotional arousal (1 = very calm to 6 = very excited). Results of a paired-samples t-test showed a significant main effect of cognitive reappraisal task instructions, $t(41) = -2.84$, $p = .007$, $d = .44$. Participants rated the negative images as lower in arousal if they had been instructed to reappraise them ($M = 3.48$, $SD = 0.65$) rather than view them ($M = 3.65$, $SD = 0.70$). We next repeated this analysis using self-reported negative valence (rather than arousal) as our unit of analysis. For this scale, higher scores reflect higher negativity (1 = neutral/not unpleasant to 6 = very unpleasant). Within this analysis, a similar pattern emerged; participants rated the images as being less negative when they were instructed to reappraise them (*M* = 3.55, *SD* = 0.70) as compared to when they were instructed to view them (*M* = 3.69, *SD* = 0.73), *t*(41) = -2.80, *p* = .008, *d* = .43. These findings replicate the results from prior studies (Ahn et al., 2015; Dillon et al., 2013; Kim & Hamann, 2012; Willroth & Hilimire, 2015).

Although instructions to use cognitive reappraisal altered self-reported emotional responses, they did not significantly affect expressive emotional behavior. This was operationalized as the mean corrugator EMG activity across the 6 seconds that the image was presented. As described above in the Procedure, a bandpass filter (20 Hz to 500 Hz; 60 Hz notch) and root mean square (100ms window) transformation was applied to the signal prior to conducting analyses. A paired-samples t-test revealed no significant difference in functional EMG response (Microvolts) when participants were instructed to reappraise the images (*M* = 2427.22, *SD* = 1902.47) compared to when they viewed them (*M* = 2430.64, *SD* = 1835.78) the images, *t*(40) = -0.17, *p* = .869, *d* = .03 (EMG activity did not properly record for one participant).

Emotion outcomes as a function of cognitive reappraisal success

We next examined the role of success in generating the cognitive reappraisals in modulating emotional outcomes. Here, we performed analyses separately on the self-reported arousal and negative valence ratings. Looking first at the arousal outcomes, results of a repeated measures (successfully reappraised vs. unsuccessfully reappraised vs. viewed) ANOVA showed significant main effects of cognitive reappraisal trial type, *F*(2, 82) = 123.11, *MSE* = 0.22, *p* < .001, η_p^2 = .75. Follow-up paired samples t-tests showed that when participants were successful at generating reappraisals they rated the images as lower in arousal (*M* = 3.09, *SD* = 0.70) as compared to when they viewed the images (*M* = 3.65, *SD* = 0.70), *t*(41) = -6.73, *p* < .001, *d* =

1.04. Conversely, when participants failed to successfully generate reappraisals they rated the images as higher in arousal (*M* = 4.68, *SD* = 0.84) compared to the images that they simply viewed, t (41) = 10.78, $p < .001$, d = 1.66, see Figure 2. The same pattern emerged for the negative valence ratings, $F(2, 82) = 190.19$, *MSE* = 0.21, $p < .001$, $\eta_p^2 = .82$. When participants were successful at generating cognitive reappraisals they rated the pictures as being less negative (*M* = 3.08, *SD* = 0.78) relative to the images that they simply viewed (*M* = 3.69, *SD* = 0.73), $t(41) = -8.40$, $p < .001$, d = 1.30. Conversely, when participants were unable to generate reappraisals they rated the images as being more negative (*M* = 4.98, *SD* = 0.86; higher valence ratings in this task reflect more negative ratings) as compared to the images they were asked to view, $t(41) = 13.38$, $p < .001$, d = 2.83, see Figure 2. As before, repeating these analyses using corrugator EMG responses as the unit of analysis yielded no significant main effect of cognitive reappraisal trial type (successfully reappraised vs. unsuccessfully reappraised vs. viewed), $F(2, 80) = 0.67$, *MSE* = 109672.63, $p = .516$, $\eta_p^2 = .02$.

Memory outcomes as a function of cognitive reappraisal task instructions

We next examined whether our instructions to reappraise the negative images enhanced participants' memory for the images (regardless of whether participants succeeded or failed at implementing our instructions). Looking first at performance during the free recall test, results showed that the main effect of emotion regulation instructions was significant, $t(40) = 3.55$, $p = .001$, d = 0.55 (due to experimenter error, one participant's recall data was lost). Participants recalled a significantly higher proportion of the negative images that they were instructed to reappraise (*M* = 0.16, *SD* = .09) as compared to the images that they were instructed to view (*M* = 0.12, *SD* = .06). We then repeated this analysis using recognition hit rates (rather than recall) as the unit of analysis. In doing so, a similar pattern emerged; hit rates proportions were higher for the images that participants were instructed to reappraise (*M* = .88, *SD* = .10) as compared to images that they were instructed to just view (*M* = .84, *SD* = .14), *t*(41) = 2.49, *p* = .017, *d* = 0.38. These findings replicate the results from prior studies for recall (Dillon et al., 2012; Willroth & Hilimire, 2015) and recognition (Hayes et al., 2010; Kim & Hamann, 2012; Richard & Gross, 2000).

As a more graded measure of recognition memory strength, we also asked participants to report their confidence during the recognition memory test (i.e., 1 = no confidence, 6 = complete confidence). Although this was done after every recognition decision, we only examined confidence ratings for images that had been shown during the cognitive reappraisal task. As in the prior analyses, there was again a significant difference as function of emotion regulation instruction condition, *t*(41) = 2.36, *p* = .023, *d* = 0.36. Participants were significantly more confident in their recognition memory decisions for the trials during which they had been instructed to reappraise the images (*M* = 5.28, *SD* = 0.46) as compared to the trials during which they had been instructed to view the images (*M* = 5.19, *SD* = 0.50).

Although instructions to reappraise enhanced memory strength (which is reflected in free recall accuracy, recognition hit rates, and recognition confidence), it did not affect source memory accuracy (i.e., of the trials correctly classified as old, the participant’s accuracy in remembering whether it had been associated with decrease or view instructions). A repeated-measures t-test revealed no significant difference in source accuracy for trials in which participants had been instructed to reappraise (*M* = .50, *SD* = .16) rather than view (*M* = .46, *SD* = .15) the image, *t*(38) = 1.12, *p* = .268, *d* = 0.18 (three participants were removed from source memory analyses due to failures to follow the task instructions). Overall, participants performed poorly on this task as chance accuracy is 50%.

Memory outcomes as a function of cognitive reappraisal success

We next tested whether success in generating cognitive reappraisals affected memory outcomes. Looking first at free recall, results of a repeated measures (successfully reappraised vs. unsuccessfully reappraised vs. viewed) ANOVA revealed a significant effects of trial type, $F(2, 80) = 4.39$, $MSE = 0.01$, $p = .016$, $\eta_p^2 = .10$. As shown in Figure 3, participants were significantly more likely to recall the images that they had successfully reappraised, ($M = .16$, $SD = .09$), $t(40) = 3.60$, $p = .001$, $d = 0.56$, compared to images that were viewed. They were also more likely to recall the images when they were unsuccessful at generating the cognitive reappraisals, ($M = .18$, $SD = .17$), $t(40) = 2.36$, $p = .023$, $d = 0.37$, as compared to when they viewed the images ($M = .12$, $SD = .06$). However, when participants were instructed to use cognitive reappraisal, there was no significant difference in correct recall as a function of whether or not they successfully implemented this strategy, $t(40) = 0.65$, $p = .520$, $d = 0.10$.

Similar patterns were observed when using recognition hit rates as the memory outcome. A repeated measures ANOVA showed a significant effect of trial type, $F(2, 82) = 3.83$, $MSE = 0.01$, $p = .026$, $\eta_p^2 = .09$. Hit rate proportions were higher when participants were successful at generating the cognitive reappraisals ($M = .88$, $SD = .10$), $t(41) = 2.07$, $p = .045$, $d = 0.32$, and also when they were unable to successfully generate the cognitive reappraisals ($M = .89$, $SD = .15$), $t(41) = 2.86$, $p = .007$, $d = 0.44$, as compared to when they simply viewed the images ($M = .84$, $SD = .14$), see Figure 3. However, hit rates did not vary depending upon whether or not participants succeeded or not in generating the cognitive reappraisal, $t(41) = -0.59$, $p = .557$, $d = 0.09$.

The same pattern emerged in the confidence ratings, but the effects here were weaker. In a repeated measures (successfully reappraised vs. unsuccessfully reappraised vs. viewed)

ANOVA, there was a significant effect on confidence ratings, $F(2, 82) = 3.13$, $MSE = 0.07$, $p = .049$, $\eta_p^2 = .07$. Confidence was significantly higher during the recognition test for the images that participants were unable to successfully reappraise during the first session ($M = 5.33$, $SD = 0.57$) as compared to images that had been viewed ($M = 5.18$, $SD = 1.25$), $t(41) = 2.30$, $p = .027$, $d = 0.36$. Confidence was also numerically higher for trials in which participants had successfully generated cognitive reappraisals ($M = 5.27$, $SD = 0.47$), as compared to images that had been viewed, $t(41) = 1.87$, $p = .069$, $d = 0.29$, however this effect was not statistically significant. Confidence ratings did not significantly vary depending upon whether or not participants had succeeded or not in generating the cognitive reappraisal, $t(41) = 1.04$, $p = .304$, $d = 0.16$.

Finally, we examined the role of cognitive reappraisal success in affecting source memory accuracy. Overall, performance was low and near chance levels (50%) and in a repeated measures (successfully reappraised vs. unsuccessfully reappraised vs. viewed) ANOVA, there was no significant differences in source memory accuracy, $F(2, 76) = 2.34$, $MSE = 0.03$, $p = .104$, $\eta_p^2 = .06$. Furthermore, source accuracy was not improved by either success ($M = .53$, $SD = .17$), $t(38) = 1.62$, $p = .113$, $d = 0.26$, or failure ($M = .45$, $SD = .19$), $t(38) = -0.19$, $p = .853$, $d = 0.03$, at generating the cognitive reappraisals as compared to when they were instructed to view the images ($M = .46$, $SD = .19$). However, when participants were unsuccessful at reappraising they were significantly less able to pair the negative image with the reappraisal instructions compared to when they succeeded, $t(38) = -2.80$, $p = .008$, $d = .45$.

Controlling for normative arousal and valence ratings

In a prior study, we found that as the normative arousal levels of negative pictures increased, people were less successful in generating situation-focused reappraisals (Opitz, et al., in preparation). For example, people were less able to generate a reappraisal for a highly arousing picture of a mutilated body as compared to a low-arousing picture of a snake. Because of this, we next tested whether our measure of reappraisal success was confounded with normative emotional ratings, and whether this could offer an alternative explanation of our results.

As in Opitz et al. (in preparation), a paired-samples t-test revealed that normative arousal ratings were significantly higher for the images that a given participant failed to reappraise (M = 6.19, SD = .25) as compared to the images that were successfully reappraised (M = 5.90, SD = .08), $t(48) = 7.46$, $p < .01$, $d = 1.53$. Likewise, normative valence ratings were also significantly lower (i.e., more negative) for images that a given participant failed to reappraise (M = 2.25, SD =.28) as compared to the images that were successfully reappraised (M = 2.76, SD = .09), $t(48) = -11.75$, $p < .01$, $d = 2.40$.

Given these differences, we next examined whether the effects of cognitive reappraisal success on emotional and memory outcomes would hold after accounting for the fact that these images differed in their arousal and valence levels. To test this, we used R and the lme4 package (Bates, Maechler & Bolker, 2012) to perform a series of linear mixed effects (LME) analyses. As fixed effects, we entered cognitive reappraisal task condition (i.e., dummy-coded Decrease vs. View instructions) into the model. To examine the role of trial-by-trial success, we entered the three cognitive reappraisal task trial types (i.e., dummy-coded for Successful vs. View, Unsuccessful vs. View, and Successful vs. Unsuccessful). Finally, normative arousal and valence ratings were entered into the model as covariates. For all models we allowed random intercepts for participants and random slopes for cognitive reappraisal task condition. The outcome measures varied in each model and included participants' arousal ratings, participant's valence ratings, proportion of images recalled, hit rate proportions, confidence ratings, and source memory accuracy. Within these models, we replicated all of the effects reported above. Furthermore, none of the patterns changed as a function of whether or not normative arousal and valence ratings were omitted versus included in the models, suggesting that the emotional and memorial consequences of reappraisal success are not (entirely) due to differences in the types of images that can or cannot be readily reappraised.

Discussion

This study examined how situation-focused cognitive reappraisals affect both emotional experience and memory outcomes, and whether these effects are modulated by self-reported success at implementing this emotion regulation strategy. Replicating some prior studies, we found that instructions to reappraise negative images were associated with both emotional and memory benefits. When participants were instructed to reappraise images they subsequently rated them as being less negative and lower in arousal as compared to images that they viewed (see also Richard & Gross, 2001). However, facial expressivity did not significantly differ as a function of these instructions. One week later, participants were also more likely to recall and recognize these images, and were more confident in their memory responses. These memory findings are consistent with those reported in some prior studies (e.g., Hayes et al., 2010; Kim & Hamann, 2012; Richard & Gross, 2000; Willroth & Hillmire, 2015).

Novel to this study, we also examined whether self-reported success in generating situation-focused reappraisals influences emotional and memory outcomes. Looking first at emotional outcomes, we found that the emotional benefits normally associated with reappraisal were only present when participants successfully generated reappraisals. In contrast, images that participants were unable to successfully reappraise were rated as more negative and higher in arousal than the images that were viewed – moreover, the detrimental effects of a failed reappraisal on emotional outcomes were about twice as large as the beneficial effects of a successful reappraisal. The fact that the self-reported emotional benefits were limited to the successful trials is not surprising. We instructed participants to label trials as “unsuccessful” when they were unable to reinterpret the meaning of the picture in a way that would reduce its negativity. Although it is intuitive that the success and emotion ratings align, the direction of these effects is unclear. It is possible that attempting, but failing, to generate a reappraisal of an image increases negative affect. Alternatively, this may simply reflect the fact that images high in negative affect are more difficult to reappraise (see also Opitz, et al., in preparation), perhaps because they are associated with fewer affordances (Suri, et al., 2017).

Regardless of the directionality of these effects, an important implication is that prior studies have likely underestimated the emotional benefits associated with situation-focused cognitive reappraisal. Prior studies have typically compared emotional outcomes from trials where participants were instructed to reappraise versus view a stimulus, but have not taken into account individual or trial-by-trial differences in success at implementing this instructed strategy. However, people are not always successful at generating cognitive reappraisals (see McRae, 2013). For example, in this study participants failed to generate situation-focused reappraisals on approximately 25% of the trials. This in turn modulated the emotional benefits associated with cognitive reappraisal. In this study, instructions to reappraise were associated with emotional benefits compared to instructions to view. However, this benefit was greater when the comparison was limited to only the trials where participants self-reported being able to successfully generate a reappraisal.

Whereas the emotional benefits associated with situation-focused reappraisals were modulated by success at implementing the strategy, the enhancements in memory accuracy were not. Even when participants were unsuccessful in generating a reappraisal, memory for the emotion-eliciting stimulus was enhanced. Participants recalled and recognized these images with greater accuracy and were more confident in their recognition responses (as compared to the images that they viewed). Furthermore, there was no difference in memory strength between the trials where participants were successful and unsuccessful in generating the reappraisal. This suggests that memory for an emotion-eliciting stimulus is improved whenever participants cognitively engage with it. When instructed to use reappraisal, participants presumably elaborated upon the picture content and thought about the possible meanings and outcomes of the depicted scene. Even when this effort did not lead to reinterpretations that reduced negative affect, the engagement with the picture content was a deep level of processing that enhanced memory accuracy. Furthermore, the fact that this enhancement in memory accuracy was equivalent both when participants succeeded and failed to generate a reappraisal is consistent with the levels of processing framework. As noted by Craik (2002), depth of processing reflects elaboration of the encoded representations but does not reflect the relative ease (or difficulty) associated with achieving that representation.

Although the effects of reappraisal on memory accuracy were only moderate in size, we argue that they are still important. Small effects can have practical importance in real world settings (Rosenthal, 1994), especially when they are cumulative (Abelson, 1985). Given that individuals regulate their emotions often and over the course of their lives, the practical benefits of cognitive reappraisal, and the implications of attempting to use this strategy on memory, may arise over time.

Although we were primarily interested in how situation-focused reappraisals affect memory strength, to gain a more complete understanding of how situation-focused reappraisals affect memory we also assessed source accuracy. Whenever participants labeled an item as “old” during the recognition test, they then decided whether they had been instructed to view or reappraise it during session one. The decisional processes involved in source memory judgments are not identical to those involved in memory recall and recognition (see Johnson, Hashtroudi, & Lindsay, 1993; Mitchell & Johnson, 2009) and factors that increase item memory accuracy do not always improve source accuracy (e.g., Jurica & Shimamura, 1999; Lindsay & Johnson, 1991; Johnson, Nolde, & De Leonardis, 1996).

In this study, we found no significant difference in source accuracy as a function of whether participants had been asked to view or reappraise the images. However, source accuracy did vary as a function of reappraisal success. More specifically, source memory accuracy followed a success > view > failure trend such that source accuracy was numerically highest in the success trials and lowest in the failure trials. One possible explanation of this pattern is that only successful reappraisals become integrated with the item memory. During the recognition memory test, participants may have evaluated whether or not their memory for each image was associated with a specific reappraisal and used this to guide their responding. If true, this suggests that participants’ overall success in generating reappraisals will determine whether or not a source memory enhancement emerges. For instance, prior research by Knight and Ponzio (2013) found that cognitive reappraisal led to an overall enhancement of source memory. Based upon our results, this could suggest that participants in the Knight and Ponzio (2013) had a high degree of success in generating the reappraisals.

These findings and implications should be considered within the limitations of the study. For one, the beneficial effects of cognitive reappraisal was limited to self-reports of negative affect. We did not find evidence that facial expressivity varied as a function of either emotion regulation task instructions or as a function of self-reported success in implementing this strategy. This raises the possibility that our findings were due to experimenter demand effects; participants may have aligned their self-reported emotions with their self-reported success in implementing the emotion regulation strategy. However, there are also alternative explanations for this null effect. For instance, physiological measures often produce smaller effect sizes than self-report (e.g., Lench, Flores, & Bench, 2011; Mauss, Wilhelm & Gross, 2004; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005), and our study may have been underpowered to observe facial expressivity differences. Furthermore, corrugator facial muscle activation is sensitive to not only valence (e.g., Cacioppo, Petty, Losch, & Kim, 1986), but also to the exertion of effort (e.g., Van Boxtel & Jessurun, 1993), and to performance monitoring (e.g., Elkins-Brown, Saunders, & Inzlicht, 2016). Although our conditions did not statistically differ in the overall quantity of corrugator activity, the underlying reasons for the facial expressivity may have differed. Finally, it is also possible that these findings reflect a lack of coherence between emotional systems; in the current study the visceral body sensations did not follow the same pattern as participants' self-reported emotions (Mauss, Levenson, Wilhelm, & Gross, 2005; Reisenzein, Studtmann, & Horstmann, 2013; Rosenberg & Ekman, 1994).

An additional limitation of this study is that we only examined success in using situation-focused reappraisals to down-regulate negative situations. All the images used in the cognitive reappraisal task were negative in valence. However, people's emotion regulation goals span a variety of situations that include up-regulation of negative and positive situations. Furthermore, it has been reported that individuals feel more successful at implementing up-regulation, rather than down-regulation, strategies to negative and neutral stimuli (Kim & Hamann, 2012). As noted earlier, there are also other forms of cognitive reappraisal (Willroth & Hillmire, 2015). Future research is needed to determine the compare the rates of success in using different forms of cognitive reappraisal to both up-regulate and down-regulate emotions to both positive and negative events in both lab and real-world settings.

It will also be important to know whether success rates in using these various strategies also modulate emotional and memory outcomes. For example, another reappraisal strategy that is commonly used in lab studies is perspective-taking, which often involves imagining situations as fake or not real. In lab studies, success in using this strategy is likely high. However, success using this strategy in real-world settings is likely lower. If success also modulates the emotional benefits of this strategy, then it is possible that lab studies over-estimate the effectiveness of this strategy for real-world settings. As for the memory benefits, as shown by Willroth and Hillmire (2015), in lab setting this strategy does not lead to memory enhancements as it does not require significant stimulus elaboration or semantic analysis. However, in real-world settings this strategy may be more cognitively effortful to implement, and may actually lead to memory benefits after all. Future research is needed to investigate these possibilities.

Although we asked participants to only use situation-focused reappraisals in our experimental task, we did not assess whether participants used alternate strategies and we did not provide specific instructions about how to respond if they used an alternate strategy. However, prior research has found that when participants are instructed to use cognitive reappraisal, they also self-report using additional (uninstructed) strategies (Opitz, Cavanagh, & Urry, 2015). In the current study this may have been especially true during the unsuccessful trials. When participants fail to quickly generate a cognitive reappraisal they may move on to a secondary regulation strategy, such as distraction. A further limitation is the possibility that participants may have spontaneously reappraised during view trials. Future research should examine when people use multiple strategies and how multiple regulation processes together affect emotion and memory outcomes. In testing this, future research should also use more ecologically valid stimuli; many of the IAPS images used in this study depict situations that rarely (or never) occur in participants' daily lives.

We also do not know why people failed to generate reappraisals for particular images. This could be due to individual differences in general reappraisal abilities, variations in the amount of effort participants exerted towards generating the reappraisals, lack of perceived affordances for particular images, or a combination of these factors. However, it is possible that these different reasons for reappraisal failures modulate the emotional and memory outcomes. For instance, situations that are unsuccessfully reappraised due to a lack of ability may be perceived less negatively as compared to situations that are unsuccessfully reappraised due to a lack of situational affordances. Likewise, situations that are unsuccessfully reappraised due to a lack of effort may be remembered less well than situations that are unsuccessfully reappraised due to a lack of situational affordances.

Understanding when people fail to generate reappraisals also has implications for cognitive behavioral therapy (CBT; Beck, Emery, & Greenberg, 1985) outcomes. A key part of this therapeutic approach is increasing patient self-efficacy in generating cognitive reappraisals (Clark & Wells, 1995; Heimberg, Brozovich, & Rapee, 2010; Hofmann, 2007, Campbell-Sills & Barlow, 2007) as a means to promotes immediate and long-term benefits for individuals with anxiety disorder (Goldin, Ziv, Jazaieri, Werner, Kraemer, Heimberg, & Gross, 2012). Future research should examine how prior experiences of reappraisal success and failure may affect a patient's self-efficacy in generating cognitive reappraisals and thus affect CBT outcomes. It will also be important to explore whether self-reports of reappraisal success match objective abilities, and why people perceive themselves as being unable to reappraise certain situations. Identifying how and why people perceive themselves as being able to use reappraisal may illuminate ways to improve cognitive reappraisal self-efficacy to help individuals suffering from anxiety.

In summary, the results of this study shed light on how self-reported success in using situation-focused reappraisal influences the way events are experienced and remembered. Considered together, our results suggest that trying, but failing, to generate a situation-focused cognitive reappraisal may be detrimental to well-being. In these situations, people feel worse and remember the situation well. Although the memory benefits associated with unsuccessfully attempting to generate a cognitive reappraisal emerges as a result of fundamental memory encoding principles, it may not be psychologically adaptive. This suggests an important limitation to the benefits of cognitive reappraisal; when failure is likely, it may be advisable to choose an alternate emotion regulation strategy.

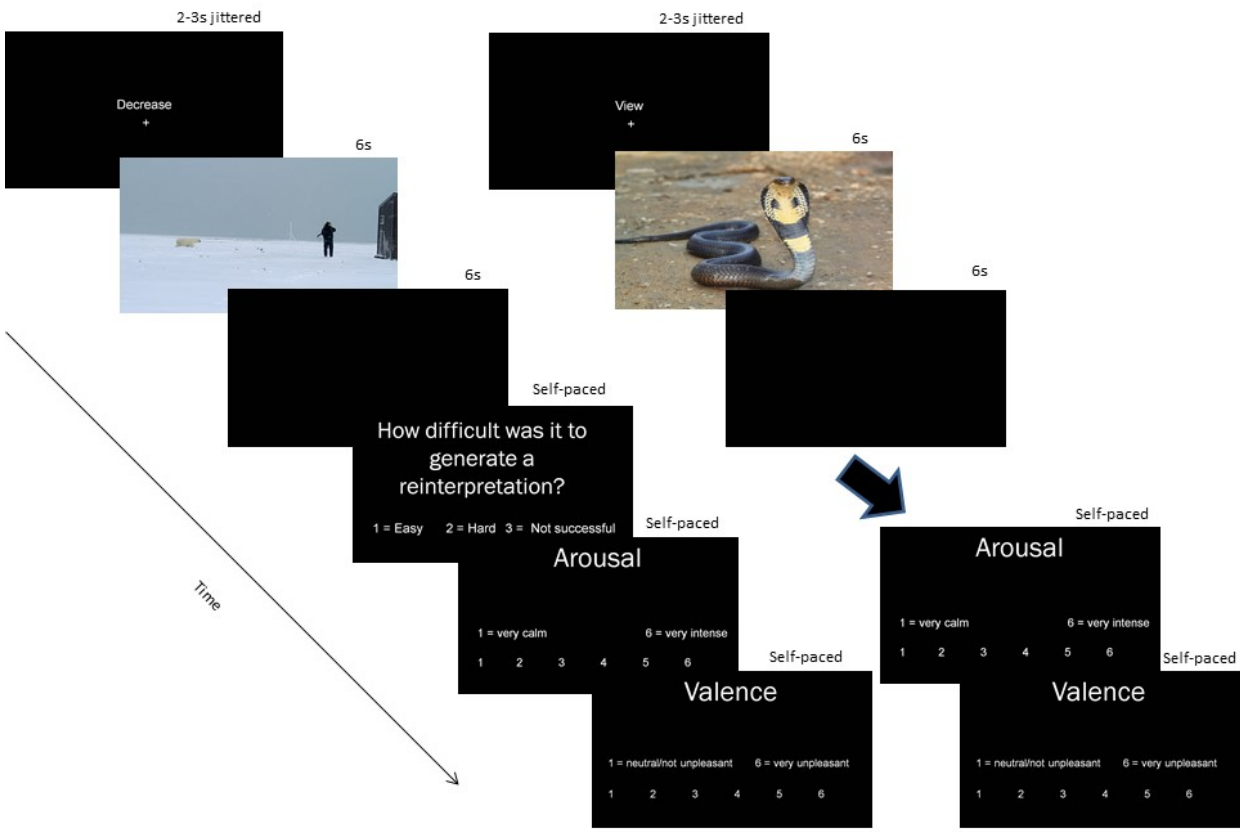

Figure 1. Trial structure and timing. Participants received a Decrease or View cue, followed by a negative image, a blank screen, a self-paced reappraisal success scale (Decrease condition only), and self-paced negative valence and arousal ratings. The images used in this figure are similar to the IAPS images used in the current study.

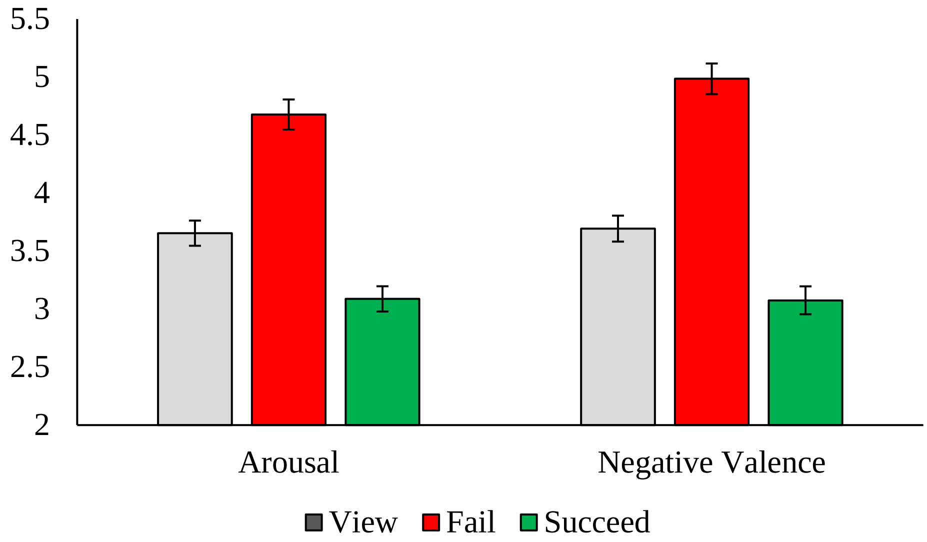

Figure 2. Mean levels of self-reported arousal (left) and negative valence (right) as a function of trial type. Error bars represent standard errors.

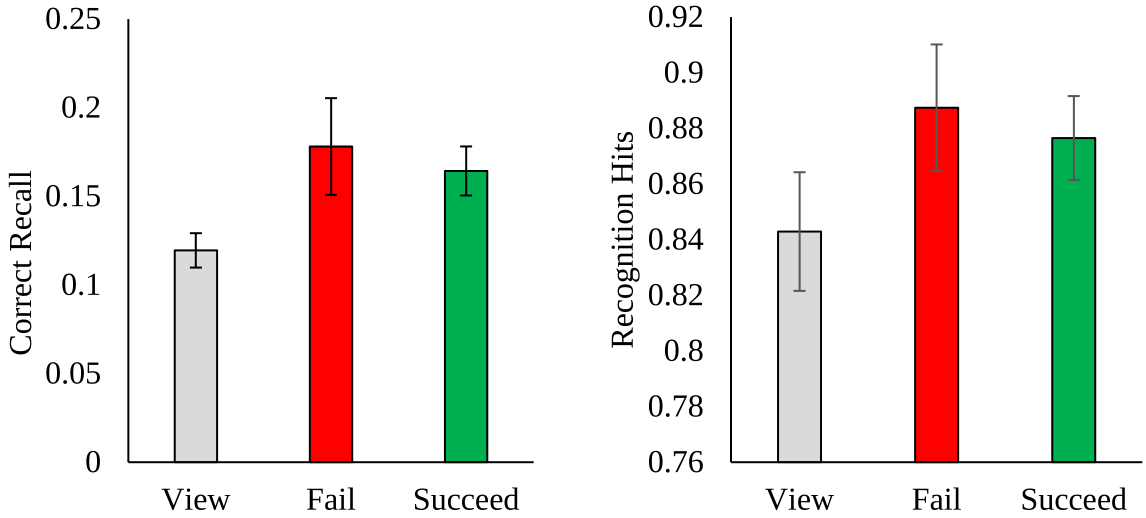

*Figure 3.*Proportion of images correctly recalled (left) and recognized (right) as a function of trial type. Error bars represent standard errors.

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