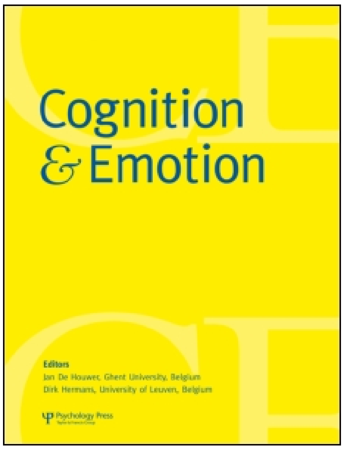

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BRIEF REPORT

The effect of cognitive reappraisal on the emotional memory trade-off

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Emotional information is often remembered better than neutral information, but this enhancement can come at the cost of memory for non-emotional stimuli presented alongside emotionally salient items. Two encoding-related factors have been proposed to influence the magnitude of this trade-off: The intensity of the affective response to the scenes (which increases the trade-off) and the cognitive control exerted to process the scenes (which decreases the trade-off). The present study examined the relative importance of these two factors by assessing the effect of cognitive reappraisal on the magnitude of the trade-off effect. Cognitive reappraisal refers to the implementation of cognitive strategies to assist a person in changing the intensity of their response to an experience. Thus, reappraisal provides a way to assess both of the factors that are important for the elicitation of the trade-off. The results revealed that when participants were asked to view the scenes, without cognitive reappraisal, a robust memory trade-off occurred. But, when participants were asked to either heighten or decrease their emotional reactions via reappraisal, there was a reduction in the magnitude of the trade-off. These results suggest that the cognitive process of reappraising the scenes is sufficient to reduce the trade-off effect, even when such processing leads to an intensified affective response.

Keywords: Affect; Emotion; Recognition; Regulation; Scene

It is well known that people show a memory enhancement for negative stimuli over neutral stimuli (see Hamann, 2001; Kensinger, 2009; Payne, Nadel, Britton, & Jacobs, 2004, for reviews). This memory enhancement, however, can come at a cost: When viewing a scene with an arousing component, memory for the arousing item is often augmented at the expense of other, less arousing, components of the scene (Kensinger, Garoff-Eaton, & Schacter, 2007; Safer, Christianson, Autry, & Osterlund, 1998). Such "trade-offs" in memory have previously been explained, in part,

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by the intensity of the affect elicited by the scenes during encoding. Easterbrook (1959), for example, hypothesised that the degree of emotional arousal elicited by an item is proportional to the attentional resources captured by it; thus, the amount of arousal elicited by the object will influence the degree to which someone's attention is narrowed onto that object. By this reasoning, the magnitude of the trade-off should be related to the amount of arousal that is experienced: The more arousing the experience, the greater the memory trade-off. In support of this hypothesis, we have shown that trade-offs happen more often, and are maintained across longer delays, for high-arousal negative valence scenes compared to low-arousal scenes (Waring & Kensinger, 2009), and that trade-offs are intensified in individuals who report high levels of anxiety while viewing the scenes (Waring, Payne, Schacter, & Kensinger, 2010).

In addition to the degree of experienced affect, cognitive control may also influence emotional memory trade-offs. Kensinger et al. (2007) found that when encoding instructions encouraged participants to process all elements of a scene—requiring them to tell a story about the scene or to describe its visual details—the trade-off was reduced. Similarly, Waring et al. (2010) found that individuals with better cognitive control, as measured by the perseverative errors made on a verbal fluency test (Monsch et al., 1992) and by subjective reports on the Dysexecutive questionnaire (Wilson, Alderman, Burgess, Emslie, & Evans, 1996), showed a less pronounced trade-off than those with poorer cognitive control. Although the cognitive control is known to assist in the regulation of emotion (Ochsner & Gross, 2005), these prior studies could not determine whether the implementation of cognitive control reduced the trade-off by reducing the amount of experienced affect (in which case a change in affect could still be the underlying mechanism through which cognitive control had its effect) or whether a more cognitively controlled manner of scene processing would reduce the trade-off even if it did not serve to reduce affective intensity.

By using a cognitive reappraisal paradigm, the present study assessed the relative importance of experienced affect and cognitively controlled processing of scenes. Cognitive reappraisal is one emotion-regulation strategy that enables individuals to change which emotions they experience, how intensely they experience them, and in what situations the emotions are experienced (Ochsner & Gross, 2005). More specifically, reappraisal involves cognitive re-evaluation or recasting of emotional stimuli in a different light, which can serve either to enhance or to diminish the intensity of the affective response elicited by the stimuli. For example, upon failing a mid-term examination, one might recast the failure as an opportunity to identify and correct a weakness in that particular area of study prior to the final examination. Such recasting might serve to reduce the intensity of the experienced negative affect by highlighting a new, positive outlook on the situation. Conversely, one might elaborate on the importance of good grades for future career pursuits and thereby intensify the experienced negative affect by increasing the importance of grades.

The success of reappraisal in augmenting or reducing the feelings of affect and their physiological correlates has been well established (Jackson, Malmstadt, Larson, & Davidson, 2000). As described by Ochsner and Gross (2005), reappraisal involves the engagement of different cognitive mechanisms that are dependent on both the person employing the strategy and the nature of a task's instructions. For instance, reappraisal could be accomplished by changing whether someone thinks about the personal impact of the adverse stimulus or instead thinks about the stimulus from the perspective of an outside observer (e.g., focusing on the personal importance of a failing grade or rather thinking about the grading distribution and the fact that someone must be at the bottom of the curve). Alternatively, reappraisal could be accomplished by reinterpreting the context of the stimulus, thereby changing its meaning (e.g., recasting the failing exam grade as an opportunity to learn).

Because the cognitive processes used for reappraisal can either increase or decrease the intensity of experienced affect (Ochsner et al., 2004), reappraisal provides a means of teasing apart the influence of affective intensity and the influence of cognitively controlled processing on the memory trade-off. This teasing apart is possible if we make two assumptions. First, we assume that affective intensity is greatest when people are instructed to increase their affect as they reappraise scenes (the *Increase* condition), that affective intensity is of intermediate strength when people are simply instructed to view the scenes (the control or *View* condition), and that affective intensity is weakest when people are instructed to decrease their affect as they reappraise scenes (the *Decrease* condition). This assumption is supported by an extensive literature demonstrating that cognitive reappraisal is an effective method for modulating the intensity of experienced affect (e.g., Giuliani, McRae, & Gross, 2008; Ochsner et al., 2004). Second, we assume that using reappraisal either to *increase* or to *decrease* affect intensity requires more cognitive control than the control condition, in which participants simply view scenes with no attempt to regulate their reactions. This assumption is based on neuroimaging studies demonstrating that using reappraisal either to increase or to decrease affect intensity results in engagement of similar regions within the prefrontal cortex that are associated with cognitive control (e.g., ventrolateral and dorsolateral prefrontal activity; Eippert et al., 2007; Kim & Hamann, 2007; Ochsner et al., 2004). These studies suggest that cognitive control and engagement of these neural regions are essential for cognitive reappraisal, regardless of whether the outcome of that reappraisal is to increase or decrease the intensity of affect.

Based on these assumptions, the present study aims to adjudicate between two competing hypotheses as follows: If affective intensity is the dominant determinant of the trade-off effect, then the magnitude of the trade-off should track the magnitude of the affective intensity experienced, being greatest in the *Increase* condition, of intermediate strength in the *View* condition, and weakest in the *Decrease* condition. By contrast, if cognitively controlled processing plays the dominant role in reducing the trade-off by means other than reducing the amount of affect experienced, then the trade-off should be reduced in both reappraisal conditions (i.e., *increase* and *decrease* conditions) as compared to the view condition.

METHOD

Participants

Data from 27 Boston College students (mean age = 20.0 years; 15 females) were included in the analyses. Data from an additional three individuals were excluded due to missing data or failure to comply with task instructions. All participants were native English speakers with normal or corrected-to-normal vision and free from any reported learning disorders, neurological and psychological conditions. Participants were not taking any medications affecting the central nervous system. Informed consent was obtained from all participants in a manner approved by the Boston College Internal Review Board.

Materials and procedure

During encoding, participants studied scenes comprised of a subset of composite pictures from Waring and Kensinger (2009) and Waring et al. (2010). On each trial, participants viewed an image consisting of a neutral background (e.g., a forest) paired with either a negative object (e.g., a snake) or a neutral object (e.g., a chipmunk) incorporated into the foreground. Pairing of negative and neutral objects was counterbalanced across participants. Objects were always placed on plausible backgrounds (e.g., a snake was shown by a forest; a car accident was shown on an avenue).

Participants viewed a total of 160 scenes where 120 included a negative foreground object and 40 included a neutral foreground object. The 120 scenes including a negative object were divided into three sets of 40 images; each set was assigned either to an emotion reappraisal condition or to the control condition. The 40 neutral scenes were always presented in the control condition, as it would not make sense to reappraise a response to a neutral image. Assignment of pictures to emotion reappraisal conditions was counterbalanced across participants (see further details below).

Practice phase. Prior to encoding, participants performed a practice task so that the experimenter could ensure that participants understood what it meant to use cognitive reappraisal as a regulation strategy. Participants were shown practice photographs followed by the instruction to increase, decrease, or view. The experimenter queried the participant about the strategies used to achieve the regulation in the increase and decrease conditions. If non-reappraisal strategies such as distraction ("I tried not to think about the photo on the screen") or suppression ("I tried to ignore the way I was feeling about the photo") were mentioned, additional clarification was provided to the participant to ensure that they were using cognitive reappraisal of the photograph to alter their affect intensity.

Encoding phase. Participants had 3 seconds to view and make an arousal rating about each scene, on a scale from 1 (*low arousal*) to 8 (*intense arousal*). Scenes then remained on the screen for an additional 8 seconds while one of three directions appeared: *increase*, *decrease*, or *view*. *Increase* required participants to interpret the images in a way that would intensify their emotional reaction (e.g., for an image of a woman yelling amidst the background of a plane crash one could imagine that she was mourning the death of a family member inside). *Decrease* required participants to interpret the images in a way that would dampen their emotional reaction (e.g., one could imagine that the passengers of the plane crash had been frightened by the crash but would all recover fully). *View* required participants to view each image without engaging in the process of reappraisal. Participants then had another 3 seconds to re-rate the scene on the same 1 to 8 arousal scale. This re-rating gives a measure of the change in their affective response as a function of the emotion reappraisal instruction.[1]

Memory-testing phase. Following the encoding phase, participants immediately performed an unexpected, self-paced, recognition memory test in which objects and backgrounds were presented separately and one at a time. Participants indicated whether each item was old (i.e., was a component of a previously studied scene) or new (i.e., it had never been seen before; as in Payne, Stickgold, Swanberg, & Kensinger, 2008). The recognition memory test included all old objects and backgrounds in addition to 60 novel negative objects, 20 novel neutral objects, and 80 novel neutral backgrounds.[2]

RESULTS

Reappraisal ratings

At the first arousal rating (prior to the instructions to reappraise), there was no difference between ratings given to the negative images that would later be associated with the *Increase* (mean = 4.47), *Decrease* (mean = 4.49), and *View* (mean = 4.74) conditions (all ts < 1.5, all ps $\geq .15$). However, as expected, negative images were generally rated as more arousing than the neutral images (Mean = 2.63), $t(26) = 9.9$, $p < .001$.

At the second arousal rating (i.e., after the regulation period), there were marked differences between ratings associated with negative images viewed under the various reappraisal instructions.

[1] A pilot study with 17 young adults indicated that demand characteristics were unlikely to contribute significantly to the pattern of these results: Participants showed a similar change in pre-ratings to post-ratings when they were told that regulation was "a task that most people found very easy" versus when they were told that regulation was "a task that most people found very hard" (all comparisons between the two conditions were highly non-significant, $p > .5$).

[2] These ratios were selected because pilot data indicated that they would lead to "old" responses for approximately 50% of the items on the recognition test, reducing the likelihood that participants would feel biased to respond "old" versus "new" simply to "even out" their responses.

Negative images from the *Increase* condition were rated as most arousing (Mean = 5.39), negative images from the *View* condition were rated at an intermediate level (Mean = 4.63), and negative images from the *Decrease* condition were rated as least arousing (Mean = 3.55). Each of these differences was significant, *Increase* vs. *View*: $t(26) = 3.31$, $p < .003$, *View* vs. *Decrease*: $t(26) = 4.65$, $p < .001$, *Increase* vs. *Decrease*: $t(26) = 9.63$, $p < .001$.

To further assess whether the emotion-regulation instructions affected arousal ratings for the stimuli, difference scores (post-rating – pre-rating) were calculated for each of the scenes. A repeated-measures analysis of variance (ANOVA) was performed with the within-subject factor of Emotion Reappraisal Condition (*Increase*, *Decrease*, or *View*). A significant effect of Reappraisal Condition was found, $F(1, 25) = 125.2$, $p < .001$. As expected, participants' arousal ratings increased in the *Increase* condition (Mean = 0.95, $SE = 0.10$), decreased in the *Decrease* condition (Mean = − 0.93, $SE = 0.09$) and showed little change in the *View* condition (Mean = − 0.07, $SE = 0.04$), suggesting that emotion reappraisal attempts were successful.

Recognition memory for scene components

We first examined whether the presence of an emotional object in a scene would produce the expected memory trade-off effect (i.e., superior memory for emotional objects at the expense of their neutral backgrounds) in the control (*View*) condition. An ANOVA was conducted with Scene Component (objects, backgrounds) and Emotion Type (negative, neutral) as within-subject factors. This ANOVA revealed significant main effects of Scene Component, $F(1, 26) = 97.5$, $p < .001$, and Emotion Type, $F(1, 26) = 4.58$, $p = .04$, qualified by a significant interaction between the two factors, $F(1, 26) = 48.2$, $p < .001$. This interaction reflects the typical memory trade-off: Negative objects were well remembered (Mean for negative objects = 0.936, Mean for neutral objects = 0.772), $t(26) = 6.39$, $p < .001$, but at the expense of their neutral backgrounds (Mean for backgrounds presented with a negative object = 0.621, with a neutral object = 0.705), $t(26) = 3.25$, $p = .003$ (see Figure 1). Thus, the results from the *View* condition replicated prior studies revealing a memory trade-off (e.g., Kensinger et al., 2007; Payne et al., 2008; Waring & Kensinger, 2009).

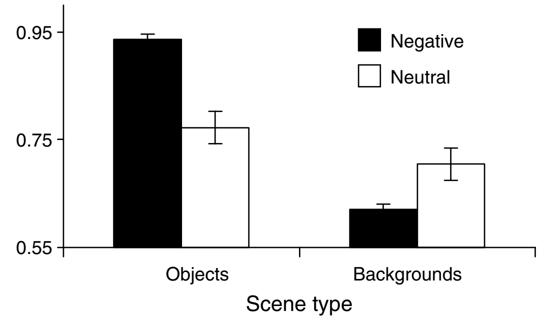

Figure 1. *Memory trade-off in view condition. When participants viewed scenes, without reappraisal, they later recognised more negative objects from the scenes than neutral objects (left side of graph). However, participants recognised fewer of the backgrounds that had been presented with an accompanying negative object compared to those that had been presented with an accompanying neutral object (right side of graph).*

To investigate whether the process of emotion reappraisal would affect the trade-off, a repeated-measures ANOVA compared memory for the components of negative scenes in each of the reappraisal conditions (*Increase*, *Decrease*) to memory for the components of negative scenes in the non-reappraisal control (*View*) condition. When comparing the *Decrease* and *View* trials, the ANOVA revealed no main effect of Reappraisal Condition (*Decrease*, *View*), $F(1, 26) = 0.132$, $p = .72$, a significant effect of Scene Component (objects, backgrounds), $F(1, 26) = 137.5$, $p < .001$, and an interaction between the two factors, $F(1, 26) = 4.68$, $p = .04$. This interaction revealed that the discrepancy in memory for objects and backgrounds of negative scenes (i.e., the trade-off effect) was less pronounced for scenes studied in the *Decrease* condition than for scenes studied in the *View* condition (see Figure 2). As compared to the *View* condition, decreasing the intensity of negative affect via cognitive reappraisal resulted in recognition of significantly fewer objects

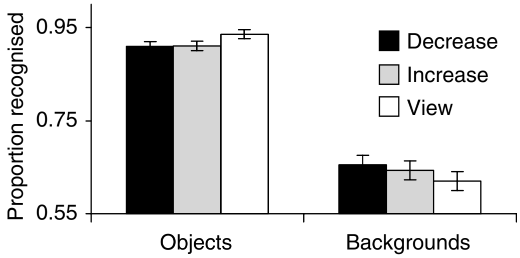

Figure 2. *Memory for negative scene components as a function of regulation condition. Memory for negative objects was best and memory for their accompanying backgrounds was worst when participants viewed the scenes compared to when they reappraised their responses. Thus, the process of reappraisal reduced the disparity in memory between the object and background components of negative scenes.*

(*Decrease* Mean = 0.910, *View* Mean = 0.936), $t(26) = 2.30$, $p = .03$, and numerically more backgrounds (*Decrease* Mean = 0.656, *View* Mean = 0.620), $t(26) = 1.42$, $p = .16$. A similar pattern of results was revealed when an ANOVA compared memory for the negative scenes studied in the *Increase* and the *View* conditions: There was no main effect of Reappraisal Condition (*Increase*, *View*), $F(1, 26) = 0.005$, $p = .94$, a main effect of Scene Component (objects, backgrounds), $F(1, 26) = 199.8$, $p < .001$, and a marginal interaction, $F(1, 26) = 3.14$, $p = .08$. Once again, memory for objects and backgrounds was more similar in the reappraisal condition than it was in the control condition (see Figure 2). As compared to the *View* condition, increasing the intensity of negative affect via cognitive reappraisal resulted in recognition of marginally fewer objects (*Increase* Mean = 0.911, *View* Mean = 0.936), $t(26) = 1.88$, $p = .07$, and numerically more backgrounds (*Increase* Mean = 0.644, *View* Mean = 0.620), $t(26) = 0.829$, $p = .41$.

An ANOVA directly comparing memory for negative scenes presented in the *Increase* and *Decrease* conditions revealed only a significant effect of Scene Component, $F(1, 26) = 131.9$, $p < .01$, with no main effect of Reappraisal Condition, $F(1, 26) = 0.181$, $p = .87$, and no interaction, $F(1, 26) = 0.256$, $p = .62$, confirming that the direction of reappraisal had no effect on memory for objects or backgrounds and thus no effect on the trade-off.

DISCUSSION

The current study revealed that the emotional memory trade-off effect—i.e., the disparity in memory between negative objects and their accompanying background—is reduced whenever participants are asked to reinterpret a scene so as to alter the intensity of their affective response. Reappraisal at encoding *reduced* the likelihood that the negative object would be remembered and *increased* the likelihood that the surrounding background would be remembered. These effects occurred regardless of whether participants used reappraisal to increase or to decrease the magnitude of their affective response. Thus, the mere exertion of cognitive control during scene processing appears to reduce the trade-off, regardless of the intensity of the affective response that results from that processing.

These findings also demonstrate that the effects of emotion regulation on memory go beyond basic enhancements or decrements in memory (see Dillon, Ritchey, Johnson, & LaBar, 2007; Richards & Gross, 2000, for a discussion of emotion regulation on memory) to affect *which* elements of an experience are later remembered. The process of cognitive reappraisal does not uniformly enhance (or impair) memory for all aspects of an experience; the overall quantity of information remembered from each scene was roughly equivalent across the different regulation conditions. Instead, the reappraisal process had different effects depending on how "central" the information was to the emotional content of an experience. Thus, reappraisal processes led to a more balanced memory for the scenes, bringing the level of memory for the negative objects and the level of memory for their backgrounds closer together, and more similar to what is typically observed for memory for the components of neutral scenes.

There are two types of mechanisms that may account for the creation of this more balanced memory representation. First, the process of cognitive reappraisal may lead to a more equal distribution of attention to all scene components, thereby reducing the tendency for participants to focus on the emotional element within the scene. Appraising the context in which the affect is being displayed may assist cognitive reappraisal. For instance, while an image of a crying woman may become more heartbreaking if you notice she is standing alone with no one to comfort her, an image of a crying woman may become less aversive if you notice a bride and groom in the background and reinterpret her expression as one of joy. More generally, asking participants to engage in cognitive reappraisal may be one way to change their goal states during scene encoding. It has been proposed (Levine & Edelstein, 2009) that participants will remember the information that is most compatible with their goals and may inhibit processing of competing information. When the person's goal is to naturalistically view and experience the emotion associated with a scene, the goal-relevant information may be the "central" emotional detail and the "peripheral" information may be interpreted as competing information. By contrast, when the person's goal is to modify the intensity of their affective response, all information in the scene may become more uniformly related to goal attainment. It is possible that this change in goal orientation may lead to a more uniform encoding of the scene elements. A second mechanistic explanation relates to how information is encoded into memory. Cognitive reappraisal has been shown to enhance non-verbal memory more than verbal memory, and to lead participants to notice global changes in scene composition (such as left/right reversal of the image; Richards & Gross, 2000). This type of visual orientation may lead to a more balanced encoding of the scene elements, leading to a more similar strength of representation of objects and backgrounds in memory.

Interestingly, the magnitude of trade-off was comparable across both the *increase* and *decrease* reappraisal conditions. This finding indicates that although affect intensity initially plays a role (Easterbrook, 1959; Waring et al., 2010), there are encoding conditions under which the intensity of affective experience is not the dominant predictor of the trade-off. Instead, here the engagement of processes needed for cognitive control were sufficient to create a more balanced memory representation of an emotional scene. It is important to note that this laboratory study used stimuli that are lower in arousal than many of the negative experiences that people would encounter in real life (e.g., seeing a snake during a hike is not the same as seeing a picture of a snake on a computer screen). Moreover, in the present study, participants had a number of seconds to process the stimuli and did not have to be concerned with planning an action in response to them. These circumstances may have made it easier for cognitive control to alter the magnitude of the trade-off effect across the range of affective intensities that we were able to sample in this study. Yet despite these limitations, the present results suggest that a complete understanding of the trade-off will require an appreciation of factors in addition to affective intensity, and that cognitive control may be an important dimension to consider.

It will be important for future research to examine whether affective intensity plays a more dominant role when scenes are presented for shorter durations of time than those used here. It is somewhat remarkable that such robust memory trade-offs were revealed here, when scenes were processed for a long period of 14 seconds. The memory trade-off has often been attributed to the visual system being bombarded with more information than it can process at once, requiring it to select the most pertinent information (discussed in Kensinger, 2009). Yet it would seem that over the course of 14 seconds, people would have sufficient time to shift attention to different scene components and to sample from most aspects of the scene. The fact that the trade-off occurs so robustly even with such a long presentation duration suggests that the effect may be attributable to more down-stream processes than simply what information is initially selected for processing. For instance, the trade-off may also be influenced by the way information is elaborated or how deeply it is processed; perhaps it is these processes that are affected when people use cognitive appraisal to change their affective response to a scene.

These results leave open the question of whether a more dominant influence of arousal intensity would be revealed if scenes were presented for a shorter duration. If arousal exerts its effects by narrowing attention onto the emotional object, then it is possible that its influence would be greater when scenes were processed more briefly. In other words, the influence of cognitive control on the memory trade-off may become more important when people have long periods of time to think about and elaborate about scene elements. If processing time is short, cognitive control processes may be less important in predicting what is remembered, and the initial allocation of attention may play a more central role. It will be important for future research to follow up on this possibility, perhaps using eye-tracking to examine how the duration of scene presentation and the engagement of cognitive reappraisal processes affects the allocation of visual attention.

In summary, we have shown that the emotional memory trade-off is particularly robust when scenes are viewed passively, without an attempt to cognitively reappraise the scenes. However, when cognitive reappraisal processes are engaged, they change how scenes are encoded and reduce the magnitude of the memory trade-off. Importantly, the effect of cognitive reappraisal on memory is the same regardless of whether these processes serve to increase or decrease the arousal a person experiences while viewing the scene. These results emphasise that the very act of engaging the processes required to regulate emotion during an experience can influence which elements of an experience are remembered later.

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