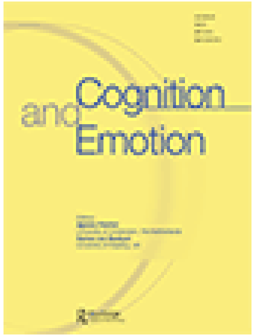

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Think again: the role of reappraisal in reducing negative valence bias

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ABSTRACT

Stimuli such as surprised faces are ambiguous in that they are associated with both positive and negative outcomes. Interestingly, people differ reliably in whether they evaluate these and other ambiguous stimuli as positive or negative, and we have argued that a positive evaluation relies in part on a biasing of the appraisal processes via reappraisal. To further test this idea, we conducted two studies to evaluate whether increasing the cognitive accessibility of reappraisal through a brief emotion regulation task would lead to an increase in positive evaluations of ambiguity. Supporting this prediction, we demonstrated that cuing reappraisal, but not in three other forms of emotion regulation (Study 1a-d; n = 120), increased positive evaluations of ambiguous faces. In a sign of robustness, we also found that the effect of reappraisal generalised from ambiguous faces to ambiguous scenes (Study 2; n = 34). Collectively, these findings suggest that reappraisal may play a key role in determining responses to ambiguous stimuli. We discuss these findings in the context of affective flexibility, and suggest that valence bias (i.e. the tendency to evaluate ambiguity more positively or negatively) represents a novel approach to measuring implicit emotion regulation.

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Our daily lives are saturated with ambiguity (Ferreira et al., 2006; Pauker et al., 2010). Across many contexts (financial, medical, interpersonal), we often have to choose between alternatives – in the absence of complete information – that are associated with both positive and negative outcomes. An individual's typical affective response to ambiguity, or valence bias, appears to have widespread implications for health and well-being. For example, a more negative valence bias (i.e. a tendency to appraise ambiguity as negative) is associated with increased symptoms of depression (Petro, Tottenham, et al., 2021) and anxiety (Park et al., 2016), as well as greater stress reactivity (Brown et al., 2017; Raio et al., 2021) and negative affect (Neta & Brock, 2021). Conversely, a more positive interpretation of ambiguity was associated with higher trait resilience and lower risk of depression (Kleim et al., 2014). Given these myriad implications of valence bias, one important question is what mechanisms give rise to these stable individual differences in responses to ambiguity.

Mechanisms underlying valence bias

Recent work has suggested that two separable psychological mechanisms might underpin individual differences in responses to ambiguity – the initial appraisal and the subsequent reappraisal (see Harp, Gross, et al., 2022), consistent with work studying

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cognitive biases (Joormann & Siemer, 2011). The first mechanism – appraisal – involves representing the motivational meaning of a situation such as how relevant, helpful, and controllable it is (Arnold, 1960; Lazarus & Alfert, 1964; Moors et al., 2013). Construction of appraisal is often an iterative process in which a coarse and fleeting appraisal is shaped into a more elaborate and stable one (Clore & Ortony, 2008; Everaert et al., 2021). The gradual unfolding of appraisal can be influenced by the second mechanism – reappraisal – which involves adjusting appraisal to be more consistent with the individuals' goals about emotional states such as the desire to avoid negative feelings (Lazarus, 1968; Safran & Greenberg, 1982; Uusberg et al., 2019). This framework represented by two separate mechanisms is consistent with extensive prior work leveraging the sequence of appraisal and reappraisal (Garland et al., 2009; Safran & Greenberg, 1982).

Although valence bias could in principle arise from individual differences in initial appraisal, it appears that reappraisal may play a dominant role. Reappraisal is often depicted as a slow, conscious, and controlled (i.e. explicit) process, but it can also be a fast, unconscious, and automatic (i.e. implicit) process (Braunstein et al., 2017). Reappraisal can thus be involved in a wide range of affective responses to ambiguity, including simple evaluations in a fast-paced laboratory task. As the evidence we review next suggests, reappraisal may indeed be involved in producing positive evaluations of ambiguous stimuli (Kim et al., 2003; Neta et al., 2009; Neta et al., 2011; Neta et al., 2021; Neta & Tong, 2016; Neta & Whalen, 2010; Petro et al., 2018; Petro, Basyouni, et al., 2021).

Empirical support for a two-stage process

First, the distinction between initial appraisal and subsequent reappraisal is evident in studies of the dynamic unfolding of affective responses to ambiguous stimuli. For instance, mouse-tracking studies revealed that, irrespective of the final evaluation, ambiguous stimuli generate an initial attraction to the negative response option (Brown et al., 2017; Neta et al., 2021). Consistent with that finding, positive evaluations of ambiguous stimuli require longer reaction times than negative evaluations, suggesting that an additional (putatively, reappraisal) process may be involved in producing an eventual positive evaluation (Harp, Langbehn, et al., 2022; Neta et al., 2009; see also Neta & Whalen, 2010).

Second, brain-imaging studies of processing ambiguous stimuli reveal that positive evaluations of ambiguous stimuli recruit more top-down regulatory brain regions relative to negative evaluations. The faster, more bottom-up signal in response to ambiguity comes from the amygdala implicating emotion generative processes such as appraisal (Neta & Whalen, 2010; Petro et al., 2018) and is associated with a more negative appraisal (Kim et al., 2003). By contrast, the more positive response is associated with greater activity in prefrontal regions that are recruited during emotion regulatory processes such as reappraisal (Kim et al., 2003; Petro et al., 2018; Petro, Tottenham, et al., 2021).

Third, some studies directly implicate reappraisal in the subsequent reduction of initial negative evaluations of ambiguous stimuli. For instance, there is some evidence that overcoming the initial negative appraisal requires cognitive control resources; participants respond more negatively to ambiguity when under high (versus low) cognitive load (Salter et al., 2022), and they respond less negatively when instructed to deliberate (i.e. invest greater cognitive resources; Neta & Tong, 2016). Recently, individual higher on trait reappraisal were found to exhibit a less negative valence bias (Harp, Gross, et al., 2022). This correlation would be expected if reappraisal indeed played a role in overcoming an initially negative valence bias. Even as many lines of indirect evidence support this idea, direct evidence linking reappraisal to valence bias is still missing.

Present research

The goal of the present research was to test the hypothesis that reappraisal is a key mechanism in updating an initial negative appraisal of ambiguous stimuli (Neta et al., 2021; Neta & Whalen, 2010; Petro et al., 2018). In testing this hypothesis, our working assumption was that cuing people to reappraise one set of stimuli would make reappraisal more cognitively accessible and thereby increase the probability that they would engage in reappraisal spontaneously when facing a new set of stimuli in close temporal proximity (Doré et al., 2016; Doré et al., 2017; Joormann et al., 2015). Specifically, in Study 1a we tested whether activation of reappraisal would lead to more positive (i.e. less negative) responses to ambiguity (H1). Then, in a series of follow-up studies (Studies 1b-d), we examined the specificity of this effect by testing our expectation that activation of suppression (H2), distraction (H3), and distancing (H4) should not influence affective responses to ambiguity. In Study 2, we tested the generalizability of findings of Study 1a by testing whether activation of reappraisal would shift affective responses to another type of stimuli (H5), namely ambiguous scenes rather than faces.

Study 1: differential effect of emotion regulation strategies on valence bias for faces

To probe the role of reappraisal in valence bias, we tested whether the bias could be shifted by experimental manipulation of the cognitive accessibility of reappraisal, and compare these effects to a manipulation that leverages three other forms of emorion regulation (suppression, distraction, and distancing). We predicted that a brief cuing of reappraisal (Study 1a), but not these other strategies (Studies 1b-d), would shift valence bias in the positive direction.

Notably, we did not expect suppression, distraction, or distancing to lead to shifts in valence bias because these strategies alter affective states by impacting components other than appraisal (Gross, 2015). Consequently, they should not increase the cognitive accessibility of the kind of reappraisal involved in adjusting fast appraisals of ambiguous stimuli. *Expressive suppression* alters affective states by targeting bodily expressions of emotion and thereby should not change the appraisals of ambiguous stimuli. *Distraction* alters affective states by diverting cognitive resources away from elaborate processing of affective stimuli. This may alter complex appraisals that depend on elaborate processing but is unlikely to alter rapid initial appraisals of common stimuli such as surprised faces (Uusberg et al., 2014). Finally, *distancing* alters affective states by increasing the level of abstraction at which the eliciting situation is represented (Moran & Eyal, 2022). Unlike reappraisal, distancing does not activate alternative interpretations of the affect-eliciting situation. Instead, it reformulates the initial interpretation in more abstract terms that place it further from the immediate experience. This strategy can be effective in reducing the intensity of emotion, but should not reverse its valence. For this reason, we did not expect that cuing distancing would alter affective responses to simple ambiguous stimuli.

Method

Participants

All participants were compensated for their participation through monetary payment or course credit. Written informed consent was obtained from each participant before the session, and all procedures were approved by the university's Committee for the Protection of Human Subjects.

Study 1a: reappraisal. Thirty-two participants were recruited from a university and the surrounding community. Previous work using a manipulation that temporarily shifts the valence bias in a within-subjects experimental design, as described by Neta et al. (2018), reported an effect size of $d = 0.74$. An *a priori* G*Power analysis for a two-tailed test of two dependent means, at 95% power and $\alpha = .05$, revealed a necessary sample size of 28 participants to replicate this within-subjects effect. Two participants were excluded for failure to participate in Session 2, and one additional participant was excluded due to non-normative ratings of clearly valenced (happy, angry) faces in Session 1 (Angry faces were rated as positive on 41.94% of trials, and Happy as negative on 58.06% of trials), resulting in a final sample of 29 participants (25 female; age range = 18-22; mean(*SD*) age = 18.93 (1.22); race = 29 White).

Study 1b: suppression. Thirty-six participants were recruited from a university and the surrounding community for Study 1b, to have a direct comparison to Study 1a. One participant was excluded due to non-normative ratings of clearly valenced (happy, angry) faces in Session 1 (Angry faces were rated as positive on 67.67% of trials, and Happy as negative on 58.33% of trials), and five participants were excluded for failure to participate in Session 2, resulting in a final sample of 30 participants (24 female; age range = 18-35; mean(*SD*) age = 20.47(3.22); race = 28 White, 2 Asian).

Study 1c: distraction. Thirty-three participants were recruited from a university and the surrounding community for Study 1c, to have a direct comparison to Studies 1a and 1b. Two participants were excluded due to non-normative ratings of clearly valenced (happy, angry) faces in Session 1 (Angry faces were rated as positive on 43.75-85.71% of trials, and Happy as negative on 54.55% of trials), and one participant was excluded for failure to participate in

Session 2. The final sample consisted of 30 participants (25 female; age range = 18-34; mean(*SD*) age = 20.47(2.90); race = 30 White).

Study 1d: distancing. Thirty-five participants were recruited from a university and the surrounding community for Study 1d, to have a direct comparison to Studies 1a-c. One participant was excluded due to non-normative ratings of clearly valenced (happy, angry) faces in Session 1 (Angry faces were rated as positive on 61.62% of trials), another was excluded due to a technical error that prevented recording of responses in Session 2, and an additional two participants were excluded for failure to participate in Session 2. The final sample consisted of 31 participants (28 female; age range = 18-28; mean(*SD*) age = 19.3(1.96); race = 34 White).

Stimuli and procedure

Participants completed two sessions approximately 1 week apart. In Session 1, participants completed the valence bias task. In Session 2, participants were first trained in reappraisal (see details below) before completing the valence bias task again on a new set of stimuli, and then completed the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). Note that the emotion regulation task was always completed in Session 2 in order to rule out any carryover effects that might occur if this task was presented instead in Session 1.

Valence bias task. As in Neta et al. (2013), stimuli included 48 pictures of faces with either an ambiguous valence (surprise, 24 pictures) or a clear valence (angry and happy, 12 of each). Fourteen distinct identities were selected from the NimStim standardised facial expression stimulus set (Tottenham et al., 2009), and 20 identities were selected from the averaged Karolinska Directed Emotional Faces database (Lundqvist et al., 1998). Genders were represented equally, though each identity was not represented in all three expressions.

The face stimuli were split into 2 subsets (24 images each) that were not significantly different from each other in terms of valence ratings ($p > .05$), consistent with previous work (Neta & Tong, 2016). One subset of 24 images was used in Session 1 (before the emotion regulation task), and the other subset was used in Session 2 (after the emotion regulation task). Both Session 1 and Session 2 contained 4 blocks of 24 trials (12 surprised, 6 happy, and 6 angry). The assignment of each subset of images to Session 1 or Session 2 was counterbalanced across all participants. Participants were asked to categorise faces as positive or negative using a 2-alternative choice button response, consistent with extensive work (Harp et al., 2021; Neta et al., 2009; Neta et al., 2013). Response assignments were counterbalanced across participants. Faces were presented for 500 ms, followed by an ISI that varied from 1500 ms to 3500 ms. Participants were able to make a response starting at the stimulus onset, and throughout the ISI period (total available response time varied from 2000 to 4000 ms) and they were asked to respond as quickly and accurately as possible. Note that accuracy was relevant only for the clearly valenced stimuli; nevertheless, this instruction was intended to promote fast but accurate responses to the task more generally. Valence bias was calculated as the percentage of all surprised trials that resulted in a negative evaluation.

Emotion regulation task. The paradigm of the emotion regulation task was adapted from Phan et al. (2005). The stimuli for the emotion regulation task were taken from the International Affective Picture System (IAPS; Lang et al., 2008). This included 40 negative ($M(SD) = 2.12(0.36)$) and highly arousing ($M(SD) = 6.08(0.54)$) images according to the normative ratings (both valence and arousal levels were rated on a scale from 1–9 with 1 = very negative/not arousing and 9 = very positive/very arousing; data from Lang et al., 2008). Note that aversive scenes were selected for the emotion regulation task rather than facial expressions because scenes are more complex and thus offer participants greater regulation affordances (Suri et al., 2018; Uusberg et al., 2019). Further, this design enables us increase the cognitive accessibility of reappraisal while minimising demand characteristics (i.e. that participants might be aware that they are expected to show more positive appraisals of ambiguous scenes following the emotion regulation task).

These 40 IAPS images were split into 2 subsets (20 images each) that were not significantly different from each other in terms of valence and arousal ratings (*ps* $> .05$), based on normative ratings (data from Lang et al., 2008). One subset was used for the Maintain blocks ("… attend to, be aware of, and experience naturally (without trying to change or alter) the emotional state elicited by the pictures"), and the other subset was used in the Regulate blocks, for which the instruction varies across Studies 1a-d. For Study 1a, participants received a Reappraisal instruction (" … regulate your emotion to lessen any negative feelings evoked by the pictures, or transform your thoughts so the pictures can bring about positive feelings", for Study 1b, participants received an Expressive Suppression instruction (" … try your best not to let your initial thoughts and feelings show. In other words, as you see the pictures, try to behave in such a way that a person watching you would not know you were feeling anything"; Ehring et al., 2010; Gross, 1998a), for Study 1c, participants received a Distraction instruction (" … think about something neutral that is irrelevant to the picture"; Webb et al., 2012), and for Study 1d, participants received a Distancing instruction (" … [view] the pictures from a detached, third-person perspective, as someone who is not affected by the picture."; Ochsner et al., 2004). Outside of these instruction differences, the procedure across Studies 1a-d were identical.

Given that there are several tactics that can be used to implement reappraisal, participants were provided with a variety of suggestions: (i) positive outcome, e.g. a man in a hospital bed had completely recovered afterward; (ii) transforming the scene into different terms, e.g. a woman crying outside of a church could be crying out of happiness at her daughter's wedding; (iii) objectifying the scene depicted in the picture, e.g. a woman being attacked by an armed man was only a movie scene. Note that this last suggestion, or reality challenge reappraisal, may share some of its effects with distancing. Like distancing, it may alter the level of abstraction at which the situation is depicted. Unlike distancing, however, reality challenge also involves a substantial change to how the eliciting situation is construed which is a hallmark of reappraisal. Participants were advised that no reappraisal tactic was applicable to all pictures, and that they should choose the tactic with which they felt most comfortable.

The assignment of each subset of images to the Maintain or Regulate blocks was counterbalanced across all participants (Maintain images for one participant would be used as Regulate images for another participant). The participants completed 8 Maintain and 8 Regulate blocks. In each block, participants saw 20s of fixation, during which they were instructed to relax and clear their mind. Then, a 4-second instruction screen appeared and notified participants whether they would complete the Maintain or Regulate task, which was followed by the presentation of 5 images (each presented for 4s). At the end of each block, participants were given 4s to rate their negative affect on a scale from 1 to 5 (1 = least negative, 5 = most negative). Before beginning this task, participants underwent a training with the experimenter, and then completed 1 Maintain and 1 Regulate practice block. The images used in these practice trials were different from the 40 images used in the experimental blocks.

Analyses

The datasets generated and/or analysed in the current study are available from the corresponding author upon request. We implemented mixed effects modelling using R's lme4 package (Bates et al., 2015) to assess whether regulation (e.g. reappraisal in Study 1a) cuing impacted affective responses to the facial expressions. These data are well-suited for mixed effects models given their nested nature. Specifically, the repeated measurements from pre – to post-regulation are nested at the subject-level, but the regulation condition itself provides nesting at the group-level. To account for within-subject variance, we included random intercepts for each subject and the crossed within-subject factors of Expression (angry, happy, surprise) and Time (Pre-Regulation, Post-Regulation). Wald's Chi-square tests, implemented in the car package (Fox et al., 2019), were used to assess main effects and interactions of model factors, and post-hoc tests were completed using the emmeans package (Lenth, 2021). We report Cohen's *d* as a measure of effect size for post-hoc comparisons, as implemented in the effect size package (Ben-Shachar et al., 2020). Given findings relating valence bias and dispositional reappraisal (Harp, Gross, et al., 2022), we report analyses with cognitive reappraisal score from the ERQ as a between-subject covariate in each model in the Supplementary Material (but note that there was no significant effect of cognitive reappraisal scores observed in any of the models). We report all *p*-values of .005 and above rounded to two decimal places.

Results and discussion

Supplementary Table 1 reports the descriptive data for the valence bias task in each session.

Study 1a: reappraisal

A linear mixed effects model with Time (Pre-Regulation, Post-Regulation), Expression (Angry, Happy, Surprise) and their interaction revealed a significant Time x Expression interaction ($X^2(2) = 9.66$, $p = .01$), such that evaluations of angry and happy faces were not significantly different across sessions (angry: $t = 0.53$, $p = .60$, 95% CI [−3.50, 6.05], $d = 0.25$; happy: $t = 0.70$, $p = .49$, 95% CI [−3.10, 6.45], $d = 0.15$), but those of surprise were more positive Post – than Pre-Regulation ($t = 4.09$, $p < .001$, 95% CI [5.04, 14.58], $d = 0.52$; see Figure 1A). We note that the surprise-specific effect survives a Bonferroni-corrected threshold for three pairwise tests ($\alpha = .02$).

In this study, we asked if increased cognitive accessibility of reappraisal generated by a short reappraisal task would shift affective responses to ambiguous stimuli. We first confirmed that the reappraisal task was effective in down-regulating negative affect in response to aversive scenes, consistent with prior literature (see Supplementary Material; Webb et al., 2012). Next, we found support for our hypothesis that participants who had completed the reappraisal task exhibited less negative affective responses toward ambiguous surprised faces compared to their initial responses one week earlier.

One limitation of the present study is that it did not have a passive control condition in which participants did not receive any emotion regulation task. However, we have assessed such a passive control condition in a previous study (see Experiment 2 in Neta et al., 2018). In a nearly identical design to the current study, participants (N = 35) completed two sessions of the valence bias task approximately one week apart; the only difference was that, in the follow-up session, participants did not receive any manipulation and completed only the valence bias task again on a new set of stimuli. We found no significant change in evaluation of any facial expression across sessions. These finding can be contrasted with the present findings to suggest that the change in evaluations of surprised faces observed here can be attributed to the emotion regulation manipulation rather than repetition or practice effects. It is also worth noting that other work has suggested that the valence bias is a trait-like characteristic such that participant's bias remained stable after one week (Neta et al., 2018) and longer timescales of six months and even one year (Harp, Freeman, et al., 2022; Neta et al., 2009). That is, repeated exposure to ambiguous stimuli does not appear to result in changes in valence bias.

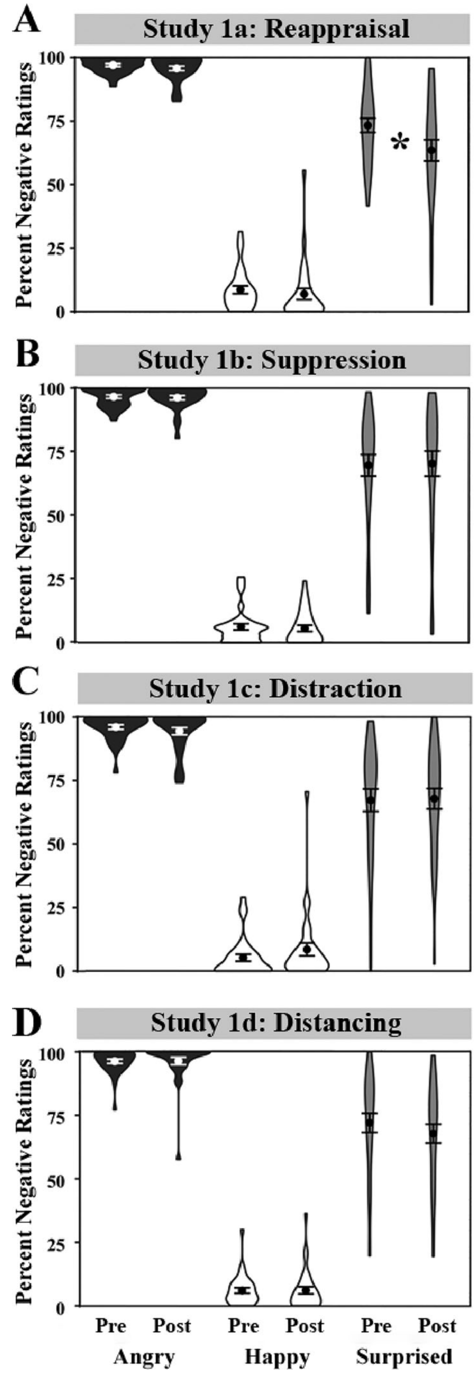

Figure 1. **A)** Study 1a evaluations of angry and happy faces were not significantly different across Time (i.e. Pre-Regulation and Post-Regulation; *ps* > .53), but evaluations for surprise were more positive Post-Regulation (after cuing reappraisal; $p < .001$). Studies 1b-d evaluations for surprised faces did not change after cuing **B)** suppression (non-significant Time x Valence interaction, $p = .86$), **C)** distraction (non-significant Time x Valence interaction, $p = .32$), or **D)** distancing (non-significant Time x Valence interaction, $p = .28$). * denotes statistical significance at $p < .001$.

Study 1b: suppression

A linear mixed effects model with Time (Pre-Regulation, Post-Regulation), Expression (Angry, Happy, Surprise), and their interaction revealed no significant Time x Expression interaction ($X^2(2) = 0.30$, $p = .86$; see Figure 1B). To further assess the nature of this non-significant interaction, we completed equivalence testing (smallest effect size of interest of +/ − 5%), specifically for the hypothesis-relevant surprised facial expressions. This analysis revealed significant tests for both the upper ($p = .01$) and lower bounds ($p = .001$), meaning that an equivalent result was obtained, suggesting there is sufficient evidence to reject the null hypothesis that the effect *does not* exceed the smallest effect size of interest.

Although there is evidence that people were able to down-regulate their self-report ratings of negatively valenced images when instructed to suppress (see Supplementary Material), unlike in Study 1a with reappraisal, cuing suppression did not have any effect on ratings of faces. This suggests that the shift toward more positive ratings of ambiguity observed in Study 1a may be somewhat specific for reappraisal, as opposed to being the result of a general propensity to regulate. In addition, this null effect provides evidence against an order effect that could have arisen as a function of the reappraisal task always appearing in the second session.

Study 1c: distraction

A linear mixed effects model with Time (Pre-Regulation, Post-Regulation), Expression (Angry, Happy, Surprise), and their interaction revealed no significant Time x Expression interaction ($X^2(2) = 2.29$, $p = .32$; see Figure 1C). Again, we assessed the nature of this non-significant interaction and completed equivalence testing for change in ratings of surprised faces. This analysis revealed significant tests for both the upper ($p = .03$) and lower bounds ($p = .01$), meaning that an equivalent result was obtained.

Similarly to Study 1a and 1b, people were able to down-regulate their self-report ratings of negatively valenced images when instructed to use distraction (see Supplementary Material) but cuing this strategy did not have any effect on ratings of faces. This provides further evidence that the shift toward more positive ratings of ambiguity in Study 1a may be somewhat specific for reappraisal, as opposed to being a result of a general propensity to regulate. Taken together, finding from Study 1b and 1c thus dissociate reappraisal not only from an response-focused and often ineffective emotion regulation strategy such as suppression but also from the more antecedent-focused and effective strategy such as distraction (Gross & Levenson, 1993, 1997; Harris, 2001; Webb et al., 2012).

Study 1d: distancing

A linear mixed effects model with Time (Pre-Regulation, Post-Regulation), Expression (Angry, Happy, Surprise), and their interaction revealed no significant Time x Expression interaction ($X^2(2) = 2.57$, $p = .28$; see Figure 1D). We again completed equivalence testing for the non-significant interaction, targeting the ratings of surprised faces specifically. Unlike the tests of equivalence for suppression and distraction, only the upper bound was significant ($p < .001$) whereas the lower was not significant ($p = .36$). As such, there is not sufficient evidence to reject the null hypothesis that the effect *does not* exceed the smallest effect size of interest for cuing distancing.

The present findings indicate that distancing also did not lead to a shift in evaluations of ambiguous faces despite being associated with effective down-regulaton of self-report ratings of negatively valenced images (see Supplementary Material). The dissociation between the effects of distancing and reappraisal is interesting because distancing has been considered to be a meta-level form of reappraisal (Koenigsberg et al., 2010; Nook et al., 2017; Powers & LaBar, 2019). Consistent with evidence that distancing is different from typical reappraisal in the brain (see Ochsner et al., 2012 for a review and Dörfel et al., 2014 for a meta-analysis), we found that only the typical form of reappraisal focusing on reinterpretation of the situation was successful in promoting more positive appraisals of ambiguity. The absence of distancing effects on ambiguity also suggests that our findings may underestimate the true effects of reappraisal on valence bias because there is a chance that the reality challenge portion of our reappraisal instructions elicited a distancing strategy that may have diluted the observable effect of reappraisal on the valence bias task.

Comparing regulation strategies

To more directly compare the effects of different emotion regulation strategies on appraisals of ambiguity, we pooled data from Study 1a-d into a secondary linear mixed effects model analysis with Time (Pre-Regulation, Post-Regulation), Expression (Angry, Happy, Surprise), Strategy (between subjects: Reappraisal, Suppression, Distraction, Distancing). We found that the Time x Strategy interaction was significant ($X^2(3) = 8.04$, $p < .05$), such that categorizations Post-Regulation were more positive than Pre-Regulation after Reappraisal ($t = 3.17$, $p = .002$, 95% CI [1.60, 6.91], $d = 0.52$), but not any of the other strategies (Suppression; $t = 0.09$, $p = .93$, 95% CI [−2.50, 2.73], $d = 0.04$; Distraction; $t = -0.56$, $p = .57$, 95% CI [−3.35, 1.87], $d = 0.04$; Distancing; $t = 1.05$, $p = .30$, 95% CI [−1.21, 3.93], $d = 0.22$. This analysis re-iterates that the shift toward more positive appraisals of ambiguity may be specific for reappraisal, as opposed to being the result of a general propensity to regulate.

One limitation of this work is that the reappraisal, suppression, distraction, and distancing conditions were conducted sequentially rather than using random assignment to conditions (i.e. the comparison across strategy was not planned a priori). A future study with random assignment is needed to fully address this limitation. However, we continue to consider the present data informative as well. The present design is open to bias if the samples of different experiments would include participants with systematically different characteristics. There are a number of reasons to doubt this is the case. All participants were recruited from the same population. The recruitment materials for all experiments were identical making it less likely that participants with different characteristics would have self-selected to participate in different studies. Finally, the equivalence of samples was supported by an analysis of ERQ reappraisal scores which did not differ between participants of Studies 1a-d ($F(3, 116) = 0.33$, $p = .80$). Thus, even as follow-up studies with random assignment are clearly needed, the present findings provide valuable preliminary evidence that reappraisal selectively leads to a reduction in negative valence bias.

An alternative explanation for these findings could be that reappraisals reduce negative affect more broadly, and that *change in affect* reduced the negative valence bias, rather than the mechanism of reappraisal being, perhaps, applied to the valence bias task. Although future research will be needed to more explicitly test this hypothesis, we suggest that this broad change in affect is not a likely explanation. First, prior work shows no evidence of reappraisal impacting mood-related influences on interpretations of ambiguity (Gordon et al., 2016). Second, if a change in affect indeed influenced evaluations in the ambiguity task, we would expect it to also shift evaluations of happy and angry faces, but our findings show a shift that is specific to surprise. Third, all four emotion regulation strategies were useful in down-regulating self-reported negative affect during the explicit emotion regulation task (see Supplementary Material), which suggests that if the mechanism were associated with a change in affect, this change in affect would be expected across Studies 1a-d. However, only the cuing of reappraisal (Study 1a) resulted in less negative responses toward ambiguity. Thus, reappraisal is a likely mechanism that promotes more positive appraisals of ambiguity.

Study 2: extending the effect of reappraisal on valence bias for scenes

Study 1 employed a measure of valence bias derived from facial expressions. However, we have proposed that these effects should not be specific to faces. In Study 2, we tested the generalizability of the effects of Study 1a by employing a different category of ambiguous stimuli. Prior work has shown that the valence bias in response to surprised faces generalises to more complex emotional scenes (Neta et al., 2013; Neta & Tong, 2016). Thus, we sought to replicate the effects in Study 1a using emotionally evocative scenes with positive, negative, and ambiguous valence. We predicted that, following the same cuing of reappraisal, participants' affective responses to ambiguous scenes would become more positive, but responses to unambiguously valenced scenes would not change.

Method

Participants

Forty-seven participants were recruited from a university and the surrounding community for Study 2, to have a direct comparison to Study 1a. Six participants were excluded due to a technical error that prevented collection of behavioural responses, three for failure to participate in Session 2, three for non-normative evaluations of unambiguously valenced (positive, negative) images in Session 1 (negative scenes were rated as positive on 50.00-79.31% of trials, and positive scenes as negative on 45.71-66.67% of trials), and one additional participant was excluded for failure to make a response on half of the trials in Session 1. The final sample consisted of 34 participants (27 female; age range = 18-35; mean(*SD*) age = 20.32(3.13); race = 33 White and 1 African-

American/Black). All participants were compensated for their participation through monetary payment or course credit. Written informed consent was obtained from each participant before the session, and all procedures were approved by the university's Committee for the Protection of Human Subjects.

Stimuli and procedure

The paradigm was identical to Study 1a, except that the valence bias task was conducted using a set of IAPS images that have been previously piloted (Neta et al., 2013) and identified as ambiguous. In other words, this subset of IAPS images show high standard deviation in valence judgments (i.e. low response consensus regarding whether the image is positive or negative across participants), longer response times in these judgments compared to judgments of more clearly valenced images, and generalizability in the valence bias from surprised faces to these scenes. As with the faces, stimuli included 48 images with either an ambiguous valence (24 images) or an unambiguous valence (negative and positive, 12 of each; for a complete list of the stimuli used, see Harp et al., 2021).[1] The images were split into two sets, so that a different set of images were presented in Session 1 and Session 2, counterbalanced across participants. Additionally, negative IAPS images used for the valence bias task were different from those used in the emotion regulation task.

Results and discussion

Supplementary Table 1 reports the descriptive data for the valence bias task in each session. A linear mixed effects model with Time (Pre-Regulation, Post-Regulation) × Valence (negative, positive, ambiguous) revealed a significant Time x Valence interaction ($X^2(1) = 8.13$, $p = .02$), such that evaluations of positive images were not significantly different across sessions (positive: $t = 0.14$, $p = .89$, 95% CI [−4.72, 5.45], $d = 0.08$). Evaluations of negative and ambiguous images were more positive Post – than Pre-Regulation (negative: $t = 2.49$, $p = .01$, 95% CI [1.30, 11.47], $d = 0.36$; ambiguous: $t = 4.08$, $p < .001$, 95% CI [5.37, 15.54], $d = 0.57$; see Figure 2), Bonferroni-corrected threshold for three pairwise tests ($\alpha = .02$).

Here, we replicated the effects of Study 1a that showed that cuing reappraisal promoted more positive affective responses to ambiguity, extending these findings from ambiguous faces to scenes. Earlier work has demonstrated that the valence bias generalises across these two categories of stimuli (Neta et al., 2013; Neta & Tong, 2016). Together, this set of findings provide stronger support for the hypothesis that reappraisal processes are involved in producing characteristically positive affective responses to ambiguous stimuli.

There was weak evidence that the manipulation shifted ratings of negative images here (but not in response to the angry face stimuli in Study 1a). This difference could be attributed to the use of IAPS images for both the emotion regulation and valence bias tasks. In other words, the reappraisal task involves encouraging participants to reinterpret negatively valenced scenes to be less negative. Later, they are asked to evaluate other negatively valenced scenes, and thus there is a greater likelihood of transference of this regulation strategy – or potential demand effects – when viewing scenes during the valence bias task than when viewing faces.

General discussion

The findings reported in this paper demonstrated that cuing reappraisal influenced valence bias whereas cuing in other regulation strategies (e.g. distraction, suppression, distancing) did not. These findings lend support to the idea that reappraisal is a candidate mechanism involved in transforming initially negative evaluations of ambiguous stimuli into a more positive valence bias at the individual level. These findings also have implications for understanding individual differences in valence bias. Previously, it was known that

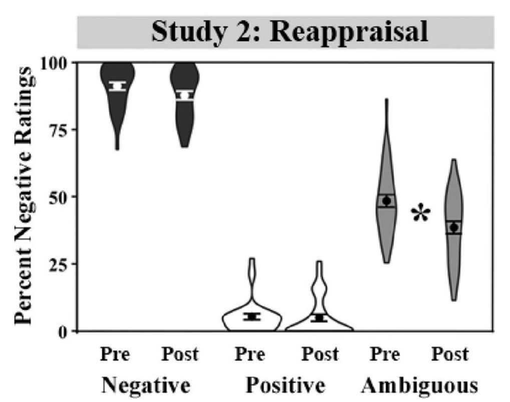

Figure 2. Study 2 replicated and extended findings to ambiguous scenes. Evaluations of negative ($p = .01$) and ambiguous scenes ($p < .001$) tended to be more positive Post-Regulation (after cuing reappraisal) than Pre-Regulation (Bonferroni-corrected $\alpha = .02$). There was no difference for positive scenes ($p = .89$). * denotes statistical significance at $p < .001$.

individuals with a less negative valence bias score higher on trait reappraisal (Harp, Gross, et al., 2022) and show greater ambiguity-related activity in brain regions associated with reappraisal (Kim et al., 2003; Petro et al., 2018). The present findings complement these earlier studies with experimental support for the idea that reappraisal, rather than alternative emotion regulation strategies (e.g. distraction, suppression), influences valence bias at the group level.

Reappraisal and responses to ambiguity

In Study 1a, we found that, after completing a brief reappraisal task with unrelated stimuli, participants' affective responses to ambiguous stimuli of surprise became more positive. This is consistent with prior work showing that a bias modification task can shift responses to ambiguous scenarios (Joormann et al., 2015) even without awareness of the modification (Grey & Mathews, 2000). We assume this effect reflects increased use of reappraisal while viewing ambiguous stimuli that was induced by the reappraisal cuing task. The task likely generated a transient increase in the activation of reappraisal-related mental representations and processes which allowed reappraisal to become more accessible during the subsequent valence bias task (but see Gordon et al., 2016, which showed no effect of reappraisal in mitigating mood-related influences on interpretations of ambiguity). In Study 2, we found that the effect of cuing reappraisal generalised from responses to ambiguous faces to ambiguous scenes.

Importantly, in Studies 1b-d we also found that cuing emotion regulation strategies of suppression, distraction, and distancing did not lead to changes in evaluations of ambiguous stimuli. This finding suggests the positive valence bias involves reappraisal specifically rather than emotion regulation more generally. Typically, suppression involves " … try[ing] not to let your initial thoughts and feelings show" (Ehring et al., 2010; Gross, 1998a), distraction involves " … think[ing] about something neutral that is irrelevant to the picture" (Webb et al., 2012), and distancing involves " … [viewing] the pictures from a detached, third-person perspective, as someone who is not affected by the picture" (Ochsner et al., 2004). It is unlikely that, in a context where participants are instructed to appraise ambiguous stimuli, they would produce a different positive appraisal by *suppressing* the initial negativity, or shifting attentional resources away from it using *distraction*, or reconstruing it in more abstract terms by using *distancing*. In contrast, reappraisal requires one to " … transform your thoughts so the pictures can bring about positive feelings" (Gross, 1998b). This process can lead to adopting a new way to appraise the ambiguous stimulus, potentially leading to a change from negative to positive appraisal.

These other regulation strategies also served as important active control conditions for the reappraisal effects in the present study. We have previously seen that the passage of time alone between sessions of the valence bias task does not induce systematic changes in valence bias. We therefore did not include this kind of passive control manipulation in the present study. Instead, we assumed that if the reappraisal cuing effects on valence bias could be explained by some generic factors unrelated to reappraisals, these factors should also reveal themselves in the three other cuing tasks which were superficially very similar to reappraisal.

Implicit vs explicit reappraisal

Our interpretation of the findings assumes that the *explicit* reappraisal participants practiced in the cuing task lead to them engaging *implicit* reappraisal in the valence bias task. This is a feasible assumption for several reasons. Even though reappraisal is often thought of as slow, conscious, and controlled, none of these are its defining features. Reappraisal, as well as other emotion regulatory behaviours, can rely on processes that range from slow, conscious and controlled (explicit emotion regulation) to fast, unconscious and automatic (implicit emotion regulation; see Braunstein et al., 2017). The brain activation associated with implicit reappraisal (Wang et al., 2017) overlaps significantly with the activation associated with explicit reappraisal (Fitzgerald et al., 2020; Morawetz et al., 2017; Silvers & Moreira, 2019). Implicit reappraisal is in fact quite common as people high in dispositional reappraisal are thought to frequently engage in implicit rather than explicit reappraisal (Gyurak et al., 2011). We therefore suggest that even a fast-paced trial in the valence bias task is sufficient for an initial appraisal to be corrected by a reappraisal process. The process is triggered by an implicit regulatory goal to change the negative affect elicited by the initial appraisal of ambiguity which recruits the cognitive processes that attempt to override it (Neta et al., 2009, 2011; Neta & Whalen, 2010).

One practical implication of the preceding discussion is that the valence bias task can be repurposed as a promising measure of individual differences in implicit emotion regulation. Existing approaches to assessing implicit emotion regulation rely on measures of conflict (e.g. an Emotional Stroop in which the words "FEAR" and "HAPPY" superimposed on presentations of fear and happy faces, in either a congruent or incongruent manner; Etkin et al., 2006; see also Bishop et al., 2007; Fitzgerald et al., 2020), or on some sort of priming mechanism that modulates one's regulatory process or goal (e.g. Bargh & Chartrand, 1999; Moore et al., 2011). Still others explore the implicit valuation of emotion regulation either in a task similar to the Implicit Attitudes Test (ER-IAT; Mauss et al., 2006), or use extinction learning as a proxy for implicit emotion regulation (Silvers, 2020). The valence bias task can be a complementary approach to characterising one's implicit emotion regulation ability that is also related to self-reported frequency in reappraisal use in daily life (albeit with a small effect size; Harp, Gross, et al., 2022).

A broader implication of the present findings concerns the role of reappraisal in producing adaptive flexibility of emotional responding in the service of enhancing well-being. Previous work has suggested that individuals with a less negative valence bias may be more flexible in considering both positive and negative appraisals of ambiguous expressions (Neta & Tong, 2016). Conversely, individuals with a more positive interpretation bias tend to use cognitive reappraisal more during social stress (Romano et al., 2020). The present findings indicate that producing such flexibility may be one of the ways in which reappraisal increases adaptiveness, which is consistent with work showing that reappraisal mediates the effect of interpretation bias on well-being (Blanco et al., 2021). An ability to flexibly replace an initial negative appraisal with a more positive reappraisal can be seen as a useful disposition. A tendency to assume the worst, that is to appraise ambiguous stimuli as if they were negative at first can be adaptive. The costs of not responding to a potential threat generally outweigh the costs of not responding to a potential reward, or more simply, eating lunch is less important than being lunch (Baumeister et al., 2001; Fox et al., 2000; Ito et al., 1998; Smith et al., 2003). At the same time, remaining chronically hypervigilant and refusing to consider the positive interpretations of ambiguous situations can also become counterproductive (Gross, 2015). It may mean lost opportunities and contribute to chronic stress and its health consequences. As such, future work should explore the role of flexible interpretations of emotional ambiguity to psychological resilience and other aspects of mental health and well-being.

Limitations and future directions

The current study has several limitations that need to be addressed with future research. The sample sizes of all studies could be increased in future studies, particularly with a better gender balance and age distribution, to further increase confidence in the present findings. Indeed, the gender imbalance, in particular, is a common issue in subject pools (Dickinson et al., 2012) so future work would benefit from recruiting a community sample. Future research should also include random assignment to cuing conditions. Additionally, the "active ingredients" in the cuing of emotion regulation administered in these studies remain somewhat unclear. A more refined version of the regulation tasks could be devised for future studies to better isolate the mechanisms contributing to a less negative valence bias. More broadly, we note that, in the context of the valence bias task, a shift toward increased positivity is conflated with reduced negativity. Future work will be needed to disentangle positivity from negativity along unipolar dimensions, though for the purposes of this work, we argue that the important effect is evident in a shift along the bipolar valence spectrum.

Another potential confound here is that the emotion regulation instructions used in Studies 1b-d (e.g. distraction: 'think about something *neutral* that is irrelevant to the picture'), were more neutral than some of those cued for reappraisal (e.g. imagining that a woman crying outside of a church could be crying out of happiness at her daughter's wedding). This distinction could partly explain the difference in the results found for reappraisal versus the other strategies, and future work might rely reappraisal tactics that emphasise down-regulating to neutral interpretations, or tactics for the other regulation strategies that evoke more positivity (e.g. for distraction: think about something *positive* that is irrelevant to the picture). Having said that, we also note that the reappraisal tactics used here were not all instructing a positive interpretation (e.g. thinking someone will make a full recovery certainly encourages a less negative response, but likely does not evoke positive emotions per se).

Several other areas remain open for future research. For example, longitudinal studies could be used to determine not only how long-lasting these effects are on valence bias, but also the point at which this cuing effect may promote a switch toward a more habitual and/or implicit form of emotion regulation (see also Supplementary Material). This work could also explore the mechanism by which either the cuing of reappraisal or trait reappraisal (or both!) operate to increase positive appraisals. For example, one likely mechanism involves promoting one's self-efficacy (consistent with findings related to cognitive-behavioural therapy; Goldin et al., 2012; Moscovitch et al., 2012), or emotion regulation expectancies (i.e. expectancy-value model of emotion regulation; Pekrun, 1992; Tamir et al., 2015; Tamir & Ford, 2012). Similarly, this cuing effect could be the first step toward changing a behaviour that may only have a transient effect on appraisals of ambiguity, but with time, if that behaviour becomes the default, trait reappraisal and valence bias may change as well. This pattern of longer-term change would be consistent with our recent work showing that other interventions that promote positive reappraisals (e.g. mindfulness-based stress reduction; see Chambers et al., 2008; Garland et al., 2009), lead to relatively long-lasting increases in a positive valence bias (Harp, Freeman, et al., 2022).

Finally, although we have offered some data to address the generalizability of our findings (ambiguous faces and more complex scenes), future work might test the effects of emotion regulation on a broader variety of ambiguous cues, including situations with high conflict or potential threat (e.g. military personnel and first responders) in which the negative response is likely adaptive, or those that might benefit from up – rather than down-regulation of emotion. For example, early work has found that people are more likely to conform to group norms when they are put in an ambiguous situation (Sherif, 1935), and independence (i.e. choosing not to conform) is associated with activity in the amygdala (Berns et al., 2005); this situation may serve as one example in which up-regulation of the initial negative appraisal could be beneficial.

Conclusions

Here, we found support for the hypothesis that reappraisal is a key mechanism in updating an initial (negative) appraisal of ambiguous stimuli (Neta et al., 2021; Neta & Whalen, 2010; Petro et al., 2018). Specifically, cuing reappraisal resulted in less negative responses to ambiguity, and this effect was specific to reappraisal (i.e. it was not evident following upon cuing suppression, distraction, or distancing). Further, the reappraisal cuing effect generalised in that it shifted responses to both ambiguous faces and scenes. This work speaks to the importance of reappraisal when faced with ambiguity, and lends support for the utility of the valence bias task in assessing individual differences in implicit emotion regulation and affective flexibility.

Note

1. Note that normative data (Lang et al., 2008) indicated that the negative images (M(SD) = 2.40(0.28) were more negative than the ambiguous images (M(SD) = 5.19 (1.29), $t(34) = 7.38$, $p < .001$), which were more negative than the positive images (M(SD) = 7.93(0.24), $t(34) = -7.27$, $p < .001$). However, there was not a significant difference between the arousal of ambiguous images (M(SD) = 4.99(0.88)) from negative (M(SD) = 5.36(0.68), $t(34) = -1.26$, $p = .22$) and positive images (M(SD) = 4.96 (0.63), $t(34) = 0.10$, $p = .92$), which also did not differ from one another ($t(22) = 1.47$, $p = .16$).

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability

Unfortunately, we did not receive participant consent to upload individual-level data, but all group-level datasets generated and/or analysed in these studies are available from the corresponding author upon request.

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