Emotion

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Emotional well-being depends on the ability to successfully engage a variety of coping strategies to regulate affective responses. Most studies have investigated the effectiveness of emotion regulation (ER) strategies that are deployed relatively later in the timing of processing that leads to full emotional experiences (i.e. reappraisal and suppression). Strategies engaged in earlier stages of emotion processing, such as those involved in attentional deployment, have also been investigated, but relatively less is known about their mechanisms. Here, we investigate the effectiveness of self-guided *focused attention (FA)* in reducing the impact of unpleasant pictures on the experienced negative affect. Participants viewed a series of composite images with distinguishable foreground (FG, either negative or neutral) and background (BG, always neutral) areas and were asked to focus on the FG or BG content. Eye-tracking data were recorded while performing the FA task, along with participants' ratings of their experienced emotional response following the presentation of each image. First, proving the effectiveness of self-guided FA in down-regulating negative affect, focusing away from the emotional content of pictures (BG focus) was associated with lower emotional ratings. Second, trial-based eye-tracking data corroborated these results, showing that spending less time gazing within the negative FG predicted reductions in emotional ratings. Third, this reduction was largest among subjects who habitually use suppression to regulate their emotions. Overall, the present findings expand the evidence regarding the FA's effectiveness in controlling the impact of emotional stimuli and inform the development of training interventions emphasizing attentional control to improve emotional well-being.

Keywords: affect, emotion control, emotion-cognition interaction, framing, affective perception

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Emotional stimuli tend to capture attention and thus affect various cognitive processes. In extreme circumstances, preferential processing of emotional information, particularly if distressing, can be associated with affective disorders, such as anxiety and depression (Lupien, McEwen, Gunnar, & Heim, 2009; Pohl, Olmstead, Wynne-Edwards, Harkness, & Menard, 2007). The impact of distressing events depends on the ability to regulate emotional responses, which influences which, when, and how emotions are experienced (Gross, 2008; Gross & Munoz, 1995). A large body of the literature on emotion control focuses on two emotion regulation (ER) strategies (cognitive reappraisal and expressive suppression; Gross, 1998). These two strategies can be understood in a framework that conceptualizes emotional processing as a sequence, beginning with a perceptual experience, followed by a stimulus interpretation ("valuation"), and then a drive to respond with an action. Within this view, cognitive reappraisal involves

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Florin Dolcos and Sanda Dolcos conceived the study; Margaret O'Brien, Alexandru D. Iordan, and Anna Madison implemented the eye-tracking design, with guidance from Simona Buetti, Alejandro Lleras, Florin Dolcos, and Sanda Dolcos; Margaret O'Brien collected the data; Paul C. Bogdan, Margaret O'Brien, Alexandru D. Iordan, Florin Dolcos, and Sanda Dolcos contributed to the analytic approach, with feedback from Simona Buetti and Alejandro Lleras; Paul C. Bogdan and Margaret O'Brien performed the analyses; Paul C. Bogdan and Florin Dolcos wrote the manuscript, with feedback from Sanda Dolcos, Simona Buetti, Alejandro Lleras, and Alexandru D. Iordan.

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interpreting negative stimuli with a more positive or neutral perspective, and suppression involves inhibiting feelings and/or behavioral responses to the negative stimuli (Gross, 1998). In this view, reappraisal is thought to operate earlier than suppression in the sequence of emotional processing events (Gross, 1998; see also Gross, 2015a, 2015b for updated views). Even earlier in this sequence, emotion can be regulated by changing one's perceptual experience through attentional deployment strategies, which have been the target of previous investigations, including several intervention studies (Bernstein & Zvielli, 2014; Sanchez-Lopez, Everaert, Van Put, De Raedt, & Koster, 2019; Sanchez-Lopez, Koster, Van Put, & De Raedt, 2019; Sanchez, Everaert, & Koster, 2016). However, relatively less is known about this approach to emotion regulation and the associated mechanisms (but see Wadlinger & Isaacowitz, 2011).

Attentional deployment strategies may be important in counteracting the attention-capturing effect of emotion, and thus reducing its detrimental impact on cognition and well-being (Pottage & Schaefer, 2012; Sheppes & Meiran, 2007; Wadlinger & Isaacowitz, 2011). Indeed, there is evidence that attentional deployment strategies may be particularly effective in controlling intense emotions (Sheppes & Meiran, 2007) and can be more easily engaged in clinical conditions where other ER strategies, such as reappraisal, may be too cognitively demanding (Beauregard, Paquette, & Lévesque, 2006; Carthy, Horesh, Apter, Edge, & Gross, 2010; Milyavsky et al., 2019; Sheppes & Meiran, 2008; Strauss, Ossenfort, & Whearty, 2016). The present study investigated the effectiveness of Focused Attention (FA) in reducing the impact of unpleasant pictures on the experienced negative affect in healthy participants. Collection of eye-tracking data allowed examination of the link between the experienced negative affect and eye-gaze associated with FA. The effectiveness of engaging FA was also investigated linked to individual differences in the habitual engagement of reappraisal and suppression (Gross & John, 2003).

Focused-Attention and Emotion Regulation

Available evidence points to the potential effectiveness of FA in counteracting the detrimental impact of unpleasant emotions. Manipulation of FA as an ER strategy involves the deployment of attention toward or away from affective aspects of stimuli, events, or memories (Denkova, Dolcos, & Dolcos, 2015; Iordan, Dolcos, & Dolcos, 2019), depending on the current regulatory goal. For example, a spectator might choose to focus on positive aspects and fully enjoy pleasant emotional experiences while watching a comedy (*up*-regulation) or to look away from the most frightening details of a horror movie to reduce the impact of distressing scenes (*down*-regulation). Given the links among attentional control, anxiety, and emotional adaptability (Derryberry & Reed, 2002; Eysenck, Derakshan, Santos, & Calvo, 2007; Mennin, Heimberg, Turk, & Fresco, 2005), FA has great potential as an ER strategy, particularly related to the down-regulation of unpleasant emotions. However, most prior research on ER strategies has largely focused on reappraisal and suppression (Gross, 2001; Webb, Miles, & Sheeran, 2012), and evidence points to increased long-term effectiveness of reappraisal as an ER strategy, compared to suppression, and increased positive health outcomes (Llewellyn, Dolcos, Iordan, Rudolph, & Dolcos, 2013). Consistent with this idea that reappraisal has been argued to operate earlier than suppression in the sequence of emotional processing (Gross, 2001, 2015a, 2015b), evidence from eye-tracking studies testing the nature of attentional engagement during reappraisal shows that this strategy is often accompanied by fixating away from negative stimuli, similar to the scan paths associated with FA (Manera, Samson, Pehrs, Lee, & Gross, 2014; van Reekum et al., 2007). Given these similarities, it is not surprising that FA, which is engaged even earlier than reappraisal, is also an effective ER strategy.

Further supporting the benefits of FA, evidence points to increased effectiveness of attentional deployment ER strategies, compared to reappraisal, in controlling the response to intense emotional stimuli (Sheppes & Gross, 2011), which may create difficulties in engaging cognitive reappraisal (Milyavsky et al., 2019; Ortner, Ste Marie, & Corno, 2016). Given that FA is also less cognitively demanding (Strauss et al., 2016), its engagement during ongoing tasks is less dependent on the availability of processing resources (Sheppes & Meiran, 2008). This may be particularly relevant for affective disturbances, which are characterized by reduced ability to voluntarily down-regulate negative emotions (Kanske, Heissler, Schönfelder, & Wessa, 2012) and difficulty in engaging reappraisal (Beauregard et al., 2006). Such challenges do not apply to FA, and previous work has also shown that subjects can be trained to reduce the processing of negative stimuli by learning new attentional habits (Lazarov, Pine, & Bar-Haim, 2017; MacLeod & Mathews, 2012). Overall, this evidence suggests that FA is well-suited as a front-line ER strategy for stressful and complex situations (Schwabe & Wolf, 2009).

Outside of the attentional retraining literature, previous studies of FA are limited in that they either employed externally guided attentional focus in processing external emotional stimuli (pictures) or self-guided focus but with internal emotional triggers (retrieved personal memories). For instance, there is evidence of dampened effects of negative stimuli by blurring negative components of images (Urry, 2010), to reduce the visual impact of emotional content, or by superimposing circles over nonemotional aspects of images, to guide the attentional focus (Ferri, Schmidt, Hajcak, & Canli, 2013). However, these findings have limited ecological validity, because it is not often the case in real-life situations that focusing away from unwanted emotional content is externally guided. Indeed, this is more likely the case in earlier ontogenetic stages when, for instance, parents may cover the eyes or ears of children to protect them from the impact of unexpected emotional encounters. Then, with training over time, people gradually develop the ability to control and self-guide their attentional focus. This highlights the importance and ecological validity of self-guided[1] FA, which is not constrained by environmental

[1] In this context, it should be noted that we distinguish between two aspects in the timeline of events associated with our conceptualization and implementation of self-guided FA: one related to the initiation of FA, which is externally cued (to focus on emotional vs. neutral aspects of images), and the other related to the actual control of the gaze behavior that determines the scanning path after FA is initiated, which is internally controlled. It is the latter aspect that our "self-guided" label refers to. Although this is not the most ecological possible version, it is an important departure from previous research mentioned above, opening the possibility that, with training, the initiation will also become internalized (Bernstein & Zvielli, 2014; Sanchez-Lopez, Everaert, et al., 2019; Sanchez-Lopez, Koster, et al., 2019; Sanchez et al., 2016; Zvielli, Bernstein, & Koster, 2015), for full ecological validity. This is similar to the ontogenetic trajectory of other aspects of self-regulation.

limitations. Previous studies from our group provided strong evidence regarding the effectiveness of self-guided FA in controlling the re-experiencing of emotional responses associated with the recollection of emotional autobiographical memories (Denkova et al., 2015; Iordan et al., 2019), as internal emotional triggers. Also, other studies used manipulation of FA with externally guided procedures in the context of ER training, to study how gaze behavior during task performance can be regulated and transferred to improve other ER strategies (reappraisal) and reduce negative emotions while viewing distressing pictures (Sanchez-Lopez, Everaert, et al., 2019; Sanchez-Lopez, Koster, et al., 2019; Sanchez et al., 2016). Complementing these studies, here we tested the effectiveness of self-guided FA in controlling the impact of ongoing external emotional stimulation, which was the first main goal of the present study.

The Role of Eye-Tracking in Understanding Mechanisms of FA

A main limitation of the FA studies with internal emotional triggers mentioned above is that they cannot measure eye movements directly linked to focusing on emotional or nonemotional aspects of the mental representations of recollected memories. This is possible, instead, with external emotional stimuli, hence allowing investigation of links between gaze-shifting and subjects' emotional reactions during FA. However, previous studies of attentional deployment have used gaze measurements mainly to confirm task compliance (Ferri et al., 2013; Urry, 2010), and thus questions remain on how gaze behavior impacts the emotional responses linked to manipulations of attentional focus. Also, previous eye-tracking studies with external emotional stimuli have focused more broadly on understanding how processing of negative stimuli is influenced by individual differences in emotional responses, and showed that, compared to healthy controls, anxious and depressed individuals tend to have increased focus on negative stimuli (reviewed in Wadlinger & Isaacowitz, 2011). Although these findings highlight the importance of measuring eye-tracking for understanding the link between the attentional focus and emotional responses, they carry two key limitations. First, they did not focus on trial-level behavior, hence preventing investigation of direct links between gaze-behavior and online experienced emotions, on a trial-by-trial basis. Second, these previous studies did not incorporate an explicit manipulation of attentional focus, hence further preventing conclusions regarding direct links between gaze patterns and emotional responses. Therefore, the second main goal of the present study was to address these issues.

The Present Study

Our study sought to clarify these open questions by manipulating self-guided FA while viewing negative and neutral images. Participants were presented with a series of composite images with distinguishable foreground (FG, either negative or neutral) and background (BG, always neutral) areas, and were asked to focus on the FG or BG content of the pictures. Eye-tracking data were recorded during this task, and participants were also asked to rate their experienced emotional response following the presentation of each image. To investigate possible links between the effectiveness of engaging FA and the habitual use of other ER strategies, individual differences in the habitual engagement of reappraisal and suppression were measured using the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). Also, given the evidence regarding alteration of attentional processes associated with symptoms of affective dysregulation (anxiety, depression; reviewed in Dolcos, Katsumi, Moore, et al., 2020), we also report exploratory analyses investigating possible links between measures indexing individual differences in these aspects and gaze behavior.

Based on the available evidence, we formulated the following predictions. First, we expected that self-guided FA would be effective in reducing the impact of negative emotional responses triggered by unpleasant pictures. In other words, focusing away, compared to focusing on, the emotional content of pictures would be associated with lower emotional ratings. Second, regarding the eye-tracking data, we expected a direct link between gaze behavior and experienced emotions, which would be identified on a trial-by-trial basis. Specifically, providing further support for the effectiveness of FA, we expected that longer time spent on the neutral BG content of images would be associated with lower emotional ratings. Finally, we also explored the following conditional hypotheses regarding the link between the effectiveness of engaging FA and individual differences in the habitual use of reappraisal and suppression. Given the evidence that reappraisal is associated with orienting away from negative content (Strauss et al., 2016), and that the effectiveness of reappraisal is inversely proportional to the level of attention directed toward negative stimuli (Manera et al., 2014; Van Reekum et al., 2007), it is possible that higher scores in ERQ-*Reappraisal* would be associated with increased effectiveness of engaging FA. Also, given the evidence that subjects scoring high in suppression tend to habitually maintain their gaze toward negative stimuli (Bardeen & Daniel, 2017), it is also possible that higher scores in ERQ-*Suppression* would be associated with decreased effectiveness of engaging FA. Alternatively, if FA's effectiveness is related to the nature of cognitive/executive operations that may be common to those associated with other ER strategies, then FA could be conceivably more effective in participants with higher scores in suppression. This is because both strategies involve inhibitory operations—that is, in the case of FA, to suppress the tendency to look at the emotional content of images (due to their attention-capturing effect) when not instructed to do so and, in the case of suppression, to inhibit the experiencing and expression of emotional responses.

Method

Participants

Forty-five[2] healthy students (20 females), ranging in age from 18 to 24 (mean age = 20.0 years, SD = 1.6 years) were recruited from the University of Illinois at Urbana–Champaign to participate

[2] Power analyses performed on data from a comparable independent pilot sample (N = 11), using typical parameters (power = .80, $p < .05$) and the "Pwr" R Package (Champely et al., 2018), estimated that a minimum of 6 participants (d = 1.75) would be required to identify significant differences in emotional ratings linked to our FA manipulation, and a minimum of 3 participants (d = 4.08) for the eye-tracking effects. The sample size in the present study exceeded considerably these minimum numbers, to allow comparisons with other reports and increased generalizability of the findings, but no power analyses were performed on the tests linking measures of individual differences to the behavioral and eye-tracking data associated with FA.

in this study (40% of the participants identified themselves as White, 31% as Asian, 16% as Hispanic, and 13% as Black). All participants were healthy, fluent English speakers with normal or corrected-to-normal vision. Data from two subjects were excluded from the eye-tracking analyses due to suspected software malfunction. Specifically, data suggested that these two participants were gazing away from images in a large proportion of trials, although no evidence of noncompliance was noted, during the task or debriefing. One of these participants was also identified as an outlier in terms of emotional ratings, based on a z-standardization outlier criterion greater than 2.5 (Seo, 2006), and was excluded from the emotional rating analyses. Finally, based on the same outlier criterion, one additional subject was excluded from the eye-tracking analyses. Hence, analyses were performed on data from 44 participants, on emotional ratings (19 females, mean age = 20.0, SD = 1.6) and on data from 42 participants, on eye-tracking effects (17 females, mean age = 20.1, SD = 1.6). Notably, the inclusion of data from the participants mentioned above would not change the statistical significance of the results or the conclusions drawn. All participants provided written informed consent under a protocol approved by the Institutional Review Board of the University of Illinois and received course credit for their participation.

Emotional Rating Task With FA Manipulation

Eye-movement data were recorded while participants viewed and rated a total of 90 composite images (60 negative and 30 neutral). Unequal numbers of emotional and neutral images have been commonly employed in studies of emotion control, particularly in those manipulating ER only within the negative condition (e.g., Eippert et al., 2007; van Reekum et al., 2007; Wager, Davidson, Hughes, Lindquist, & Ochsner, 2008). The main goal of this study was to elucidate the impact of FA as an ER strategy. As such, we included equal numbers of negative images viewed under FG focus versus BG focus to maximize the number of negative images for the main targeted comparison. However, the inclusion of neutral images in the design was also necessary to avoid prolonged negative mood induction and to have them as a basic control condition. Hence, we sought to have equal numbers of trials for the main three categories of images involved (Emotional FG, Emotional BG, and Neutral), which was also justified by pilot data showing no significant differences in the emotional ratings between the FG and BG foci for the neutral images.

Each composite image was created by overlaying a negative or neutral FG component upon a visually complex BG component. The FG components were extracted from images part of the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008), the Geneva Affective Picture Database (GAPED; Dan-Glauser & Scherer, 2011), the Military Affective Picture System (MAPS; Goodman, Katz, & Dretsch, 2016), the Nencki Affective Picture System (NAPS; Marchewka, Zurawski, Jednorǒg, & Grabowska, 2014), and the Emotional Picture Set (EmoPicS; Wessa et al., 2010). Images from these sources along with domain-free online image databases were used as BG components. Negative and neutral composite images were matched for human presence, animacy (e.g., animals vs. objects), FG location (i.e. top, bottom, left, right), complexity, brightness, and contrast (all $p_s > .05$). Also, given the multiple sources used for the creation of the composite pictures, a validation study was performed on a separate group of participants (N = 19), who evaluated the valence and arousal associated with the emotional and neutral images using the same 9-point Likert scale. Based on this validation study, we ensured that the emotional images were negatively valenced and arousing, while neutral images were appropriately neutral and nonarousing, and that the images in the FG and BG conditions had similar properties. Emotional images were reliably more negatively valenced (M_{Valence} = 2.46, SD_{Valence} = .79) and more arousing (M_{Arousal} = 4.95, SD_{Arousal} = 1.05) than the neutral images (M_{Valence} = 4.79, SD_{Valence} = .48; M_{Arousal} = 2.17, SD_{Arousal} = .46; $ps < .001$). The pool of 90 images was divided into sets of images that were randomly assigned to five study runs, counterbalanced across image type and attentional cue categories. The run orders were randomly assigned to the participants. To avoid negative mood induction, the order of trials was pseudorandomized within each run, so that no more than three images of the same emotional category or cue type were presented consecutively. Each image was presented for 4 s and then was removed to minimize possible confounding effects of eye movements associated with prolonged scanning of images (see Figure 1).

Participants were asked to view each image under different attentional manipulation conditions, cued by the preceding instruction screen. The cues (.5 s) directed them to focus either on the image foreground (FG Focus), which was emotional or neutral, or on the image background (BG Focus), which was always neutral. Half the negative images and half the neutral images were preceded by a FG focus cue and the other halves were preceded by a BG focus cue. The cue type preceding each image was counterbalanced across participants. Following image presentation, participants were asked to rate their subjective emotional experience triggered by the images on a 5-point scale (1 = *Not Negative at All*, 5 = *Very Negative*). All responses were made on a computer keyboard. About one week later, a subsample of participants returned for a surprise memory test, which is the focus of a different report.

Eye-Tracking Data Acquisition

To assess participants' gaze patterns during the emotional rating task, eye positions and movements were recorded from each participant's right eye using the Eyelink1000 system (SR Research, ON, Canada), at a sampling rate of 1000 Hz. A pseudorandom 9-point calibration was performed at the beginning of the experimental session and after every other experimental block. The monitor's diagonal measures 21,″ corresponding to 43 degrees of visual angle at the participant's viewing distance of 58 cm. Fixations and saccades were determined using a displacement threshold of 0.1°, a velocity threshold of 35°/s, and an acceleration threshold of $9{,}500°/s^2$ (SR Research Ltd, Ottawa, Canada).

Individual Differences Measures

To investigate possible links between the effectiveness of engaging FA and the use of other ER strategies, individual differences in the habitual engagement of reappraisal and suppression were measured using the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). Participants also completed other

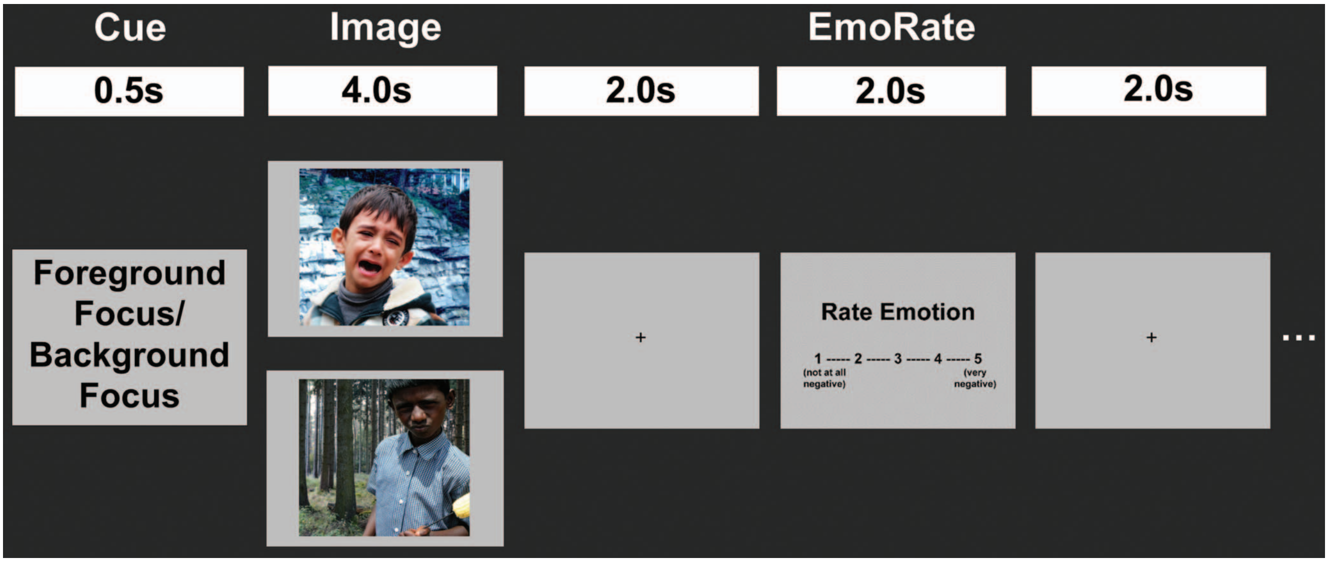

Figure 1. Task Diagram. Participants were asked to view each image as cued by a preceding instruction screen (FG Focus or BG Focus). After viewing each image, participants rated their emotional experience on a 5-point scale (1 = *Not Negative at All*; 5 = *Very Negative*.). From "The impact of focused attention on emotional experience: A functional MRI investigation." by F. Dolcos, Y. Katsumi, C. Shen, P. Bogdan, S. Jun, R. Larsen, . . . S. Dolcos, 2020, *Cognitive, Affective, & Behavioral Neuroscience*, Copyright 2020 by Springer Nature in Cham, Switzerland. Adapted with permission. See the online article for the color version of this figure.

questionnaires, as part of a short neuropsychological battery including the State–Trait Anxiety Inventory (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1970), the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), and the Penn State Worry Questionnaire (Meyer, Miller, Metzger, & Borkovec, 1990). Although their investigation was not the main focus of the present report, we report exploratory analyses investigating possible links among these measures and with gaze behavior.

Data Analyses

The effects of the image type (emotional vs. neutral) and FA manipulation on participants' emotional ratings were assessed in SPSS using repeated-measures ANOVAs and post hoc paired *t* tests. The effects associated with participants' gaze patterns linked to the FA manipulation were assessed by calculating both the proportion of fixations within the FG/BG areas of images and the proportion of time spent gazing the in FG area, using the EyeLink Data Viewer. Both gaze measures are reported to provide a more holistic representation of gaze-behavior, even though they were highly correlated on a trial-by-trial basis ($r = .93$). Similar to the assessments of the effects on emotional ratings, initial analyses tested whether these gaze metrics were impacted by the image type and/or the FA manipulation, based on calculating overall averages. Then, the same procedures were applied for every 20 ms time window within the 4000 ms image presentation period to identify the time course of subjects' gaze behavior over the course of the trial. Then, trial-by-trial analyses on the data related to the emotional ratings and gaze metrics were performed using hierarchical linear regressions, both with and without the effect of the attentional cue included as a predictor. These multilevel regressions were carried out using R (R Core Team, 2013), the "Lmer" (Bates, Mächler, Bolker, & Walker, 2014), and the "LmerTest" (Kuznetsova, Brockhoff, & Christensen, 2017) R packages. In addition, the data used for both the paired *t* tests and the hierarchical regressions were repurposed to also investigate the effects of individual differences on FA's effectiveness. Specifically, for each subject, the difference between their average emotional ratings for the Emotional FG and the Emotional BG trials (indexing the extent of emotional reaction dampening associated with the BG focus) were first calculated. Then, these values were correlated with the subjects' ERQ scores; similar analyses were also performed with other measures of individual differences (STAI, PSQW, BDI). Lastly, we also adapted the multilevel models to investigate the effects of individual differences in both ERQ subscales (reappraisal and suppression) and their interaction terms with the gaze predictors, to assess their ability to predict the emotional ratings. Confidence intervals for the partial eta-squared and Pearson correlation effect sizes were calculated using the "MBESS" R package (Kelley, 2007), and the confidence intervals for the Cohen's *d* effect sizes were calculated in Microsoft Excel based on the equations described by Goulet-Pelletier and Cousineau (2018).

Results

Reduced Emotional Ratings Following the Engagement of FA

Confirming our first prediction, self-guided FA was effective in reducing the impact of negative emotional responses triggered by unpleasant pictures—specifically, focusing away from the emotional content of pictures (BG Focus) was associated with lower emotional ratings (see Figure 2). Consistent with these, a 2-way

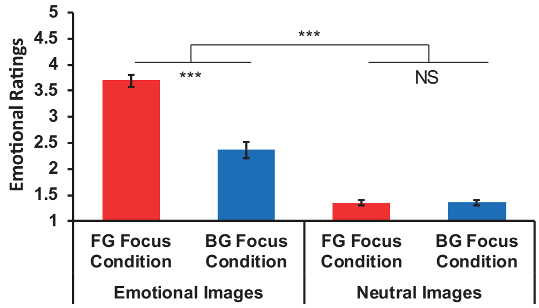

Figure 2. Reduced Emotional Ratings following FA. Differences in the emotional rating scores for emotional and neutral pictures, linked to the FA manipulation (FG vs. BG Focus), are illustrated. Error bars indicate the standard error of the means. FA = Focused Attention; FG = Foreground Focus; BG = Background Focus; *** $p < .001$. NS $p > .05$. See the online article for the color version of this figure.

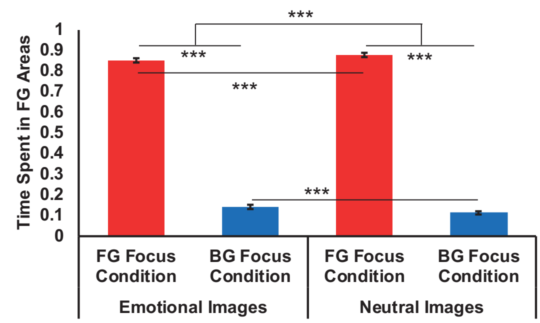

Figure 3. Gaze Behavior Linked to the FA Manipulation: Time Spent in FG Areas. Consistent with the task instructions, participants spent more time in the FG than the BG areas of images following the FG Focus cues. Similarly, participants spent more time in the BG that the FG areas of images following the BG Focus cues (not shown, see Table 1 for a complete report of results). FG = Foreground; BG = Background; *** $p <$ .001. See the online article for the color version of this figure.

ANOVA yielded significant main effects of Image Type (Emotional vs. Neutral; $F(43) = 331.7$, $p < .001$, partial eta-squared effect size (η^2_p) = .89 95% CI [.81, .92]) and FA Manipulation (FG Focus vs. BG Focus; $F(43) = 66.5$, $p < .001$, $\eta^2_p = .61$ [.41, .72]), as well as a significant Image Type × FA Manipulation interaction ($F(43) = 78.8$, $p < .001$, $\eta^2_p = .65$ [.46, .75]). Post hoc comparisons showed that the effects of FA occurred only in the emotional, $t(43) = 8.6$, $p < .001$, $d = 1.4$ [1.1, 1.7], but not in the neutral $t(43) = -.1$, $p = .89$, $d = -.01$ [−.14, .12] images.

Reduced Emotional Experience Linked to Averted Gaze Behavior

Manipulation check. First, confirming task compliance, eye-tracking data showed that participants successfully directed their gaze toward the target components of both emotional and neutral images. Namely, when instructed to focus on the FG, participants spent more time gazing within the FG than the BG areas, and when instructed to focus on the BG areas, they spent more time gazing within the BG than the FG areas (Table 1 and Figure 3; for simplicity, only data for the times spent in the FG areas are illustrated in the main text—see online supplemental materials, for additional details). Confirming these numerical differences, a 2-way ANOVA on the data regarding the time spent in the FG areas of images yielded a nonsignificant main effect of Image Type ($F(41) = .15$, $p = .70$, $\eta^2_p = .00$ [.00, .11]), a significant main effect of FA manipulation ($F(41) = 1840.0$, $p < .001$, $\eta^2_p = .98$ [.96, .98]), and a significant Image Type × FA Manipulation interaction ($F(41) = 29.7$, $p < .001$, $\eta^2_p = .42$ [.19, .59]). Further confirming that participants followed the FA manipulation instructions when viewing both emotional and neutral images, post hoc comparisons showed that participants spent more time gazing within the FG areas when instructed to do so (FG Focus) than when instructed to focus on the BG areas (BG Focus), for both emotional ($t(41) = 36.4$ $p < .001$, $d = 9.1$ [8.6, 9.6]) and neutral ($t(41) = 47.6$ $p < .001$, $d = 12.0$ [11.5, 12.4]) images. Similar analyses performed on the data regarding the time spent in the BG areas of images provided further support for instruction compliance (see also Figure S1 in online supplemental materials), as did analyses on the number of fixations within the FG or BG areas (see Table S1 and Figure S2 in online supplemental materials).

In addition to these overall effects demonstrating participants' compliance with task instructions, we also found evidence for increased ability to perform the FA task with neutral images, compared to emotional images. This is confirmed by the significant Image Type × FA Manipulation interaction mentioned above ($F(41) = 29.7$, $p < .001$, $\eta^2_p = .42$ [.19, .59]) and by further post hoc analyses. Specifically, as also illustrated in Figure 3 (compare the blue bars), participants spent more time in the FG areas of emotional than neutral images, $t(41) = 4.6$, $p < .001$, $d = .37$ [.21, .53], even when instructed to focus on the BG content. This finding is consistent with an attention-capturing effect of emotion, which led to increased difficulty to keep the attentional focus away from the emotional content of images. Moreover, participants were able to spend more time in the FG areas of neutral than emotional images, $t(41) = 4.2$, $p < .001$, $d = .33$ [.18, .49], when instructed to focus on the FG content (compare the red bars in Figure 3). This

Table 1
Proportion of Time Spent Within the FG/BG Areas of Emotional and Neutral Images, Linked to FA Manipulation

	FG Focus			BG Focus		
Gaze measure	Negative	Neutral	All	Negative	Neutral	All
FG time (%)	.85 (.08)	.88 (.08)	.86 (.08)	.14 (.08)	.11 (.06)	.09 (.08)
BG time (%)	.09 (.05)	.08 (.04)	.09 (.05)	.78 (.05)	.81 (.04)	.79 (.05)

Note. FA = focused attention; FG = foreground; BG = background. Values represent the time spent in each area divided by the length of the presentation period (4 s) and indicate means (standard deviations).

is possibly due to the aversive nature of the negative images, which is consistent with a gaze-aversion effect of emotion. Again, similar patterns were also identified in the number of fixations within the FG and BG areas linked to the FA manipulation (see online supplemental materials: Table S1 and Figure S2). Finally, further analyses investigating the time course of these effects also identified timing-related differences in the attention-capturing and gaze-aversion effects of processing emotionally unpleasant images (Figure S3 in online supplemental materials), with the former being prominent throughout the whole trial length and slightly stronger during the first half of image presentation and the latter largely occurring during the second half of image presentation. Overall, these findings show that participants performed the FA task as instructed and that they were better able to direct their gaze as cued if the image was neutral.

Evidence linking reduced emotional experience with averted gaze behavior. Confirming our second prediction, longer time spent on the BG content of emotional images was associated with lower level of experienced emotions. This direct link between gaze behavior and experienced emotions was identified by a trial-level hierarchical linear model, which revealed that increased BG gaze time was associated with dampened emotional ratings for emotional, $t(41) = -8.4$, $p < .001$, $\beta = -1.63$ [−2.01, −1.25] but not for neutral, $t(41) = .3$, $p = .74$, $\beta = .02$ [−.08, .11] images (see Figure 4). These results were confirmed when also accounting for the instructional cue as a predictor, $t(41) = -2.5$, $p = .018$, $\beta = -0.36$ [−.64, −.07]. Finally, as in the case of manipulation check analyses, similar results were found for the proportion of BG fixations (Figure S4 in online supplemental materials).

Increased FA Effectiveness Linked to Habitual Use of Suppression

Finally, analyses exploring the link between the effectiveness of engaging FA and individual differences in the habitual use of reappraisal and suppression confirmed the "cognitive/executive account" of our conditional hypotheses. Specifically, we found that participants who tend to use suppression as a habitual emotion control strategy (as reflected in higher scores of ERQ-*Suppression*) also showed larger reductions in experienced emotion following the engagement of FA to focus away from the emotional content of emotional images ($p = .018$, $r = .35$ [.05, .59]). As illustrated in Figure 5, there was a positive correlation between the ERQ-*Suppression* scores and the decrease in the emotional ratings associated with the BG Focus compared to FG Focus, for emotional but not for neutral images ($p = .94$, $r = -.01$ [−.29, .31]). This link was also confirmed by the multilevel model analyzing the emotional image trials, which revealed a significant BG Gaze × ERQ-*Suppression* interaction effects on emotional ratings on a trial-by-trial basis (BG Time × ERQ-*Suppression* interaction: $p = .006$; BG fixations × ERQ-*Suppression*: $p = .008$). In other words, subjects who tended to use suppression showed a stronger link between BG gaze time/fixation proportion and decreased Emotional Ratings. These effects were nonsignificant for the neutral trials (ps $> .22$). Importantly, similar analyses including the subjects' ERQ-*Reappraisal* scores were not significant for emotional images ($p = .88$, $r = -.03$ [−.33, .28]) or for neutral images ($p = .93$, $r = .01$ [−.29, .32]), which was corroborated by nonsignificant findings associated with the Gaze Behavior × ERQ-*Reappraisal* interactions in the multilevel model, for both negative and neutral images ($p_s > .90$). Additional exploratory correlation analyses can be found in the online supplemental materials.

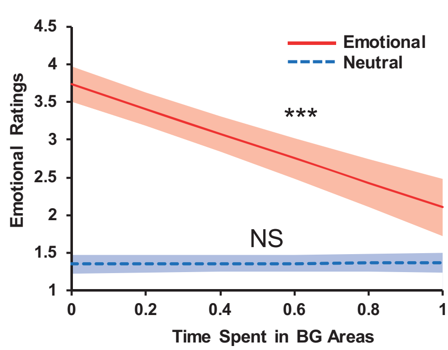

Figure 4. Reduced Emotional Experience linked to Averted Gaze Behavior: Time Spent in BG Areas. Longer time spent gazing within the BG areas, and away from the emotional content, was associated with reduced experienced emotions for emotional but not for neutral images. Shaded area represents the 95% confidence interval. BG = Background; *** $p < .001$. See the online article for the color version of this figure.

Discussion

The present study targeted the impact of manipulating self-guided attentional focus on the subjective emotional experience associated with viewing unpleasant images, using affective self-report and eye-tracking assessments, in conjunction with measures of individual differences. There were three main novel findings. First, results on the reported negative experience showed that focusing away from the emotional content of pictures (BG Focus) was associated with lower emotional ratings. Second, trial-level analyses linking the emotional ratings and eye-tracking data showed that longer time spent on the BG content of emotional images was associated with lower levels of experienced negative affect. Third, investigation of individual differences in emotion control using correlation analyses regarding the attentional cue effects and trial-by-trial multilevel analyses of gaze behavior offered converging evidence that increased effectiveness in focusing on the nonemotional content of images was linked to the habitual use of suppression as an emotion regulation strategy. Below, we discuss these findings in detail.

Emotional Ratings Following the Engagement of FA

By finding that FA dampens the subjective emotional experiences associated with viewing unpleasant emotional images, we extend previous studies using attentional deployment strategies to regulate emotional responses. First, the present results extend findings from studies involving externally guided attentional focus (Ferri et al., 2013; Urry, 2010) by providing strong evidence that self-guided FA can be engaged effectively to control the impact of unpleasant emotional images. This is important because self-guided FA has increased ecological validity and can be performed outside the laboratory. Second, the present results also complement previous studies using FA with internal stimulation (Denkova et al., 2015; Iordan et al., 2019) by showing that it can also

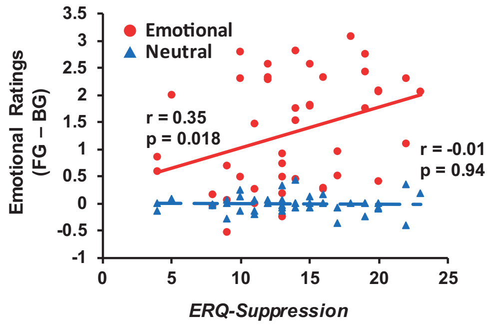

Figure 5. Increased FA Effectiveness Linked to Habitual use of Suppression. Participants with higher ERQ-*Suppression* scores also showed larger reductions in emotional ratings following the engagement of FA to focus away from the emotional content of emotional images. FA = Focused Attention manipulation; FG = Foreground; BG = Background; ERQ = Emotion Regulation Questionnaire. See the online article for the color version of this figure.

be used to regulate emotional responses to external negative stimuli and also highlight the role of trial-level gaze behavior in these responses. These strengths, coupled with evidence that subjects can learn to habitually avoid negative external stimuli (Browning, Holmes, Murphy, Goodwin, & Harmer, 2010; Cristea, Kok, & Cuijpers, 2015; MacLeod & Mathews, 2012; Wadlinger & Isaacowitz, 2011), contribute to the translational value of FA.

Our exploratory analyses also provided new insight into the duality of emotion's effects on attention by revealing that the attention-capturing or averting effect of emotional content was influenced by the FA cue. This is important because it highlights the importance of considering the experimental context when assessing the impact of emotion on attention and provides possible explanations for discrepant findings showing opposing effects of negative stimuli on gaze behavior. Previous studies showed that presenting negative and neutral images alongside one another causes subjects to spend increased time gazing toward the negative stimuli (reviewed in Carretié, 2014). However, other studies found that subjects with phobias resist fixating on fear-inducing images, even when instructed to do so (Tolin, Lohr, Lee, & Sawchuk, 1999). Our findings show that opposing effects can be identified with the same experimental design and highlight the need to consider factors that may cause such effects. Overall, these results provide insight into possible future investigations of the mechanisms associated with dual effects of emotional stimuli on gaze-behavior and add to a large emerging literature identifying opposing effects of emotion on cognition (Dolcos & Denkova, 2014, 2016; Dolcos, Iordan, & Dolcos, 2011; Dolcos et al., 2013; Dolcos, Katsumi, Denkova, & Dolcos, 2017; Shafer & Dolcos, 2012).

Reduced Emotional Experience Linked to Averted Gaze Behavior

The results linking gaze-behavior to the processing of negative stimuli offer key insight into clinical work relating gaze-behavior and negative experience. Unlike most research in this area (e.g., Kellough, Beevers, Ellis, & Wells, 2008; Wadlinger & Isaacowitz, 2011), the present study used a trial-by-trial procedure to measure within-subject relations between gaze behavior and emotional response. This allowed for finer assessment of the link between gaze behavior and emotional responses, linked to manipulations of FA as an ER strategy and adds to the evidence regarding the utility of ER interventions that train individuals to focus away from negative stimuli (MacLeod & Mathews, 2012). Previous studies implementing such interventions have typically involved training subjects to develop a bias against negative stimuli by administering a task where subjects succeed by preferentially attending neutral stimuli. Then, the success of the intervention is measured by having participants report their emotional reactions to negative stimuli. It should be noted that, while there is evidence that such training dampens the effect of negative stimuli in healthy (Browning et al., 2010) and clinical groups (Cristea et al., 2015), meta-analytical findings raise questions regarding their overall efficacy in reducing subjects' negative experience (Beard, Sawyer, & Hofmann, 2012). Also, because typically these studies do not record eye-tracking (but see Chen, Clarke, Watson, MacLeod, & Guastella, 2015), they raise questions about whether the emotional dampening is due to shifts in gaze behavior or to some alternative non-gaze-related mechanisms (Vrijsen et al., 2019). The present study supports the idea that gaze behavior indeed plays a role in this dampening and offers insight into possible mechanisms of gaze-based interventions.

Interestingly, more recent training regimens that provide feedback during training, indicating participants whether they are successfully reorienting their gaze or not, show promising results (Lazarov et al., 2017). Our results extend this line of research by demonstrating a direct link between gaze behavior and negative affect and are consistent with evidence that feedback may increase the effectiveness of emotion regulation. More broadly, our findings provide strong empirical support to previous research on attentional bias retraining using FA with external negative stimuli to improve the ability to transfer retrained habitual patterns to future contexts (Bernstein & Zvielli, 2014; Sanchez-Lopez, Everaert, et al., 2019; Sanchez-Lopez, Koster, et al., 2019; Sanchez et al., 2016). Additionally, our findings provide direct support for the role of manipulating gaze to external stimuli using FA to also alter the impact of ongoing emotional events.

Increased FA Effectiveness Linked to Habitual Use of Suppression

The findings regarding increased effectiveness of FA in the participants with higher suppression scores, identified with both correlation and trial-by-trial interaction analyses, are also important because this ER strategy is typically seen as having maladaptive long-term consequences (Llewellyn et al., 2013; Moore et al., 2018; Richards & Gross, 1999; but see Yuan, Liu, Ding, & Yang, 2014). At first, this result may seem somewhat surprising, as our findings are not consistent with evidence that habitual use of expressive suppression is related to higher gaze maintenance (rather than avoidance) of negative material (Bardeen & Daniel, 2017), which points to difficulties in shifting attention away from negative information in habitual suppressors. However, the maladaptive long-term consequences of habitually engaging suppression do not exclude the possibility of short-term effectiveness, such as in the case of facilitating the deployment of FA, as it is the case in the present results and consistent with other findings (Yuan et al., 2014). Moreover, the link between FA and suppression is reasonable to expect if we consider that both involve inhibitory operations and their execution is associated with similar neural responses in top-down brain regions, such as the dorsolateral prefrontal cortex (Dolcos, Katsumi, Bogdan, et al., 2020; Iordan et al., 2019; Vanderhasselt, Kühn, & De Raedt, 2013).

It should be noted that suppression is a type of "avoidance strategy", which may seemingly only be appropriate for conferring immediate benefits but might have maladaptive long-term consequences, as it is associated with increased symptoms of dysregulation (Aldao & Nolen-Hoeksema, 2012; Llewellyn et al., 2013; Werner, Goldin, Ball, Heimberg, & Gross, 2011). There is evidence, though, that the use of attentional deployment ER strategies does not necessarily promote avoidance but may actually promote approach behavior. This idea is supported by results showing that the use of such strategies in exposure therapy sessions promotes perceived control and self-efficacy (Johnstone & Page, 2004; Oliver & Page, 2003) and increases the rate of approach behavior in follow-up sessions (Oliver & Page, 2008). One possibility is that attentional retraining does not actually promote systematic attentional avoidance but rather allows subjects to disengage from negative stimuli in a healthy manner (Amir et al., 2009), a skill impaired in high-anxiety clinical populations (Amir, Elias, Klumpp, & Przeworski, 2003). These disengagement patterns are consistent with our data, as regardless of the attentional cue, subjects initially focused on emotional aspects of stimuli before disengaging from them if prompted to focus on contextual aspects of the images (see online Supplemental Materials Figure 3).

The present findings point to the usefulness of suppression that may uniquely benefit some aspects of emotion control and contribute to the literature identifying beneficial effects of engaging it along with other specific ER strategies (Klumpp et al., 2017; Yuan et al., 2014). This is important because it opens up the possibility of using personalized training/interventions to enhance ER and coping abilities (Doré, Silvers, & Ochsner, 2016; Goubet & Chrysikou, 2019; Klumpp et al., 2017). For instance, such interventions could capitalize on incorporating knowledge regarding the role of individual differences in the impact of training on habitual gaze behavior linked to emotional sensitivity. Given the present link between suppression and the effectiveness of engaging FA, it is possible that individuals with higher ERQ-*Suppression* scores would benefit from complementary training in other effective ER strategies, such as cognitive reappraisal. This would counteract the long-term negative outcomes of using suppression (Aldao & Nolen-Hoeksema, 2012; Llewellyn et al., 2013; Werner et al., 2011), while capitalizing on its beneficial link with the effectiveness of FA and on long-term positive outcomes of reappraisal (Llewellyn et al., 2013). Such training would create a more well-rounded set of ER strategies to be used flexibly, with both immediate and long-term effectiveness.

Overall, the present results extend basic evidence on the relation between gaze behavior and experienced emotions and carry translational and clinical relevance. While more research is needed to distinguish the benefits of FA linked to suppression from maladaptive long-term consequences of the latter, in healthy and clinical groups, evidence from the present and related studies points to both immediate and long-term benefits of FA in reducing the impact of distressing emotions, reflected in reduced experienced affect and recollection of unpleasant internal and external stimuli, respectively (Denkova et al., 2015; Dolcos, Katsumi, Bogdan, et al., 2020; Dolcos, Katsumi, Shen, et al., 2020; Iordan et al., 2019).

Limitations

One limitation of the present study is that the emotional content was presented only in the FG of the images. Ideally, it would have been to also manipulate the emotional content of the BG areas, so that possible effects linked to this limitation could have been ruled out. Nevertheless, this caveat does not limit the conclusion of the present study, given the careful selection and creation of the emotional and neutral stimuli that allowed direct comparison of their effects. Another limitation is that the present study did not directly compare FA with other ER strategies. However, collection of data regarding the subjects' habitual use of other emotion regulation strategies made it possible to link suppression with increased effectiveness of engaging FA to reduce the impact of negative emotions triggered by emotional visual stimuli. Another minor caveat is that there were fewer neutral than emotional trials (see Methods). Although this does not alter the main conclusions, it is a potential confounder for comparability in the present 2 (Emotion) × 2 (Focus) ANOVA design. Finally, it must also be noted that additional investigations are needed to confirm the findings regarding individual differences, most of which were exploratory. This is particularly the case for the analyses linked to changes in gaze behavior, which were carried out without correcting for multiple comparisons. Future studies with FA manipulations would benefit from full manipulation of the emotional content of stimuli in both FG and BG locations, direct comparisons with other ER strategies, and using an equal number of emotional and neutral trials, as well as from employing larger samples to fully clarify the role of individual differences in the FA's effectiveness.

Conclusion

To our knowledge, this is the first empirical study targeting the effects of self-guided FA on external stimuli and the associated eye-gaze mechanisms, to alter the emotional impact of ongoing emotionally eliciting events. First, the present findings provide initial evidence regarding the effectiveness of self-guided FA in reducing the impact of unpleasant emotional images on the experienced negative affect. Second, trial-level analyses of the eye-tracking data showed that longer time spent focusing on the neutral contextual details of emotional images predicted lower levels of experienced negative affect. Third, investigation of individual differences in emotion control showed that increased effectiveness in focusing on the nonemotional content or images was linked to habitual use of suppression as an emotion regulation strategy. Overall, the present findings extend the evidence regarding the FA's effectiveness in controlling the impact of emotional stimuli, advance our understanding of the link between gaze behavior and subjective emotional experience, and inform the development of training interventions emphasizing attentional control. More generally, this initial study investigating the effectiveness of self-guided FA in reducing the emotional impact of ongoing unpleasant external stimuli linked to eye-gaze mechanisms provides strong empirical support to training studies aimed at increasing emotion control abilities to improve well-being.

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