Supplementary Material

1. Questionnaires

Participants completed the 90-item Mood and Anxiety Symptom Questionnaire (MASQ; Watson and Clark, 1991, Watson, Clark, Weber, Smith Assenheimer, Strauss and McCormick, 1995) and the 20-item Attentional Control Scale (ACS; Derryberry & Reed, 2002).

The MASQ-90 assesses anxious, depressed, and mixed symptoms, general distress, anxious arousal, and anhedonic depression (Watson et al., 1991). On a scale from one to five, where one equals “not at all”, and five equals “extremely”, participants rate how much they have experienced each item in the week prior to testing. Items include “felt confused” (general distress), “hands were shaky” (anxious arousal), and “felt like nothing was enjoyable” (anhedonic depression). Across samples of undergraduate students, adults, and clinical samples, all MASQ sub-scales have shown good reliability (Cronbach’s alphas ranging from .78 to .93) (Watson et al., 1995).

The ACS (Derryberry & Reed, 2002) assesses voluntary control over attention and has subscales cataloguing attentional shifting and attentional focusing. Participants rate each item on a scale from one to four, where one equals “almost never” and four equals “almost always”. Items include “It’s very hard for me to concentrate on a difficult task when noises are around,” and “It takes me a while to get really involved in a new task.” The ACS has shown good reliability (Cronbach’s alpha = .88).

2. Additional Analyses

2.1 Effects of picture valence on valence ratings

Mean ratings of valence for view unpleasant and view neutral trials (averaged across gaze direction conditions) were submitted to a multivariate GLM to assess the main and interactive
effects of picture valence (unpleasant, neutral; within-subjects) and age group (younger, older; between-subjects). The GLM revealed a significant main effect of picture valence, $F(2,28) = 296.30, p < .001, \eta^2 = .91$. The highest rating of 3 indicates negative valence. Thus, unpleasant pictures, $M = 2.73, SD = .27$, were rated as more unpleasant than neutral pictures, $M = 1.72, SD = .29$. There was no significant effect of age group, $F(1,29) = 1.87, p = .187, \eta^2 = .06$, and no significant interaction between valence and age group, $F(1,29) = 2.08, p = .160, \eta^2 = .07$.

2.2 Effects of reappraisal goal, age group, and gaze direction on valence ratings

The main effect of reappraisal goal on valence ratings for the unpleasant picture trials was significant, $F(2,28) = 8.78, p < .001, \eta^2 = .39$. Judgments of valence were more negative during the increase, $M = 2.87, SD = .20$, compared to view, $M = 2.73, SD = .27, p < .001$, condition. The difference between the view and decrease, $M = 2.75, SD = .24$, conditions was not significant, $p = .355$. Gaze direction did not interact with reappraisal goal, $F(2,28) = .56, p = .58, \eta^2 = .04$.

2.3 Are the age differences in neural activation above driven by age differences in spatial extent?

Samanez-Larkin and D’Esposito (2008) noted that older adults may exhibit smaller spatial extents of activation within an ROI compared to younger adults. As a result, mean activation calculated across the entire ROI may be artificially lower for older than younger adults due to inclusion of very low signal change in many voxels for older adults. Thus, we submitted estimates of peak signal change to the same analyses reported above. The pattern of findings remained unchanged, which suggests that age differences in spatial extent of activation within the two ROI do not explain the age differences in mean percent signal change.

2.4 What did participants actually do when asked to reappraise?

To determine whether participants used cognitive reappraisal as instructed, we examined
the strategies participants reported using when instructed to increase or decrease their response to the unpleasant pictures.

For increase reappraisals, seven participants (22.58%; 4 younger, 3 older) indicated imagining themselves or loved ones in the depicted situations, 18 participants (58.06%; 8 younger, 9 older) reported imagining the depicted situation to be very negative, or getting worse in the near future, and five participants (16.13%; 2 younger, 3 older) reported nonspecific reappraisals such as “tried to increase how I felt.” Three participants (8.33%; all younger adults) reported focusing on specific parts of the scene to increase their emotions.

For decrease reappraisals, 17 participants (54.84%; 6 younger, 11 older) reported imagining the situation as being not as severe as it appeared, or improving in the near future. Three participants (9.68%, all younger adults) indicated imagining suffering coming to an end. Five participants (16.12%; 4 younger, 1 older) reported imagining the situation being “fake” or “pretend”, two participants (6.25%; both older adults) reported nonspecific reappraisals, and one participant (3.22%; younger adult) described “distancing myself” from the scene internally. Three participants (6.45%; 1 younger, 2 older) reported focusing on specific parts of the scene to decrease their emotions.

These data collectively suggest that participants largely used cognitive reappraisal to increase and decrease their unpleasant emotion. A few participants relied on attention-based regulation strategies, thus underscoring the importance of analyzing the dot detection data to determine if there were differences in attentional deployment across reappraisal conditions and/or age groups.

2.5 Do age differences in a third variable account for age differences in CR?

There were age differences in dot detection performance (increase > view for older
adults). In addition, as shown in Supplementary Table 1, there were age differences in measures of mood/anxiety symptoms and attentional control (older < younger for MASQ; older > younger for ACS). Thus, to evaluate whether the age differences we observed in reappraisal-related differences in intensity ratings and neural activation were explained by these variables, we recalculated Cohen’s d effect sizes for the age difference with the influence of these covariates partialled out and examined the extent to which the age difference effect sizes changed.

The effect size for the age difference in the increase – view contrast score for intensity ratings was reduced from Cohen’s d = .53 to d = .276, a difference of 48%. Similarly, the effect size for the age difference in the view – decrease contrast score for intensity ratings was reduced from Cohen’s d = .343 to d = .174, a difference of 49%. In left ventrolateral PFC, the effect size for the age difference in reappraisal-related activation was reduced from Cohen’s d = .515 to d = .282, a difference of 45%. In dorsal medial PFC, the effect size remained essentially unchanged, going from Cohen’s d = .307 to d = .309, a difference of less than 1%. This pattern collectively indicates that the size of the age difference was reduced when controlling for dot detection performance, and MASQ and ACS scores. However, these variables do not fully explain the age differences we observed.

2.6 Is the age difference in prefrontal activation driven by increase or decrease reappraisals?

Independent samples t-tests (one-tailed) to evaluate the age difference for (increase – view) and (decrease – view) separately indicated that, in left VLPFC, the age difference was significant for both increase reappraisals, $t(29) = 3.06, p = .005$, and decrease reappraisals, $t(29) = 2.19, p = .04$. In DMPFC, the age difference was significant for increase reappraisals, $t(29) = 2.05, p = .049$, but not for decrease reappraisals, $t(29) = 1.02, p = .32$. See Supplementary Table 2 for effect sizes.
2.7 Does directing gaze impact subjective emotion experience or prefrontal activation?

Consistent with Urry (2010), participants rated trials as more intense when gaze was directed to an arousing area, \( M = 2.67, SD = .59 \), compared to when gaze was directed to a non-arousing area, \( M = 2.59, SD = .57 \), of the picture, \( F(1,29) = 5.69, p = .02, \eta^2 = .16 \). In left ventrolateral PFC, participants showed marginally higher mean estimates of % BOLD signal change when gaze was directed to an arousing, \( M = .60, SD = .13 \), compared to when gaze was directed to a non-arousing, \( M = .14, SD = .13 \), area of the picture, \( F(1,29) = 3.27, p = .08, \eta^2 = .11 \). Similarly, in dorsal medial PFC, participants showed marginally higher estimates of % BOLD signal change when gaze was directed to an arousing area of the picture, \( M = .11, SD = .14 \), compared to when gaze was directed to a non-arousing area of the picture, \( M = .09, SD = .13 \), \( F(1,29) = 3.41, p = .075, \eta^2 = .11 \). These results indicate that gaze direction by itself manipulates emotion experience and, to some degree, activation in these two regions of PFC, although lack of statistical power meant only marginally significant neural effects. These results also provide validation of our a priori “arousing” and “non-arousing” AOI, which were originally validated by Urry (2010) in a separate sample of younger adults.

Supplementary Material References


Supplementary Table 1
Characteristics of the sample

<table>
<thead>
<tr>
<th>Measure</th>
<th>Younger</th>
<th>Older</th>
<th>Significant Age Difference?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD) age in years</td>
<td>19.25 (1.43)</td>
<td>59.87 (3.14)</td>
<td>( t(18.548) = -43.6, p &lt; .001 )</td>
</tr>
<tr>
<td>( N )</td>
<td>16</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>8</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Women</td>
<td>8</td>
<td>8</td>
<td>( \chi^2(1) = .034, p = .853 ) (2x2: sex by age group)</td>
</tr>
<tr>
<td>Highest Level of Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school diploma</td>
<td>2 (12.5%)</td>
<td>1 (6.6%)</td>
<td></td>
</tr>
<tr>
<td>Some college</td>
<td>14 (87.5%)</td>
<td>7 (46.6%)</td>
<td>( \chi^2(2) = 13.58, p = .001 ) (3x2: education by age group)</td>
</tr>
<tr>
<td>College diploma or higher</td>
<td>0 (0%)</td>
<td>7 (46.6%)</td>
<td></td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single (never married)</td>
<td>16 (100%)</td>
<td>1 (6.6%)</td>
<td>( \chi^2(2) = 27.23, p &lt; .001 ) (3x2: marital status by age group)</td>
</tr>
<tr>
<td>Married</td>
<td>0</td>
<td>7 (40%)</td>
<td></td>
</tr>
<tr>
<td>Divorced</td>
<td>0</td>
<td>7 (46%)</td>
<td></td>
</tr>
<tr>
<td>Self Report Measures</td>
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</tr>
<tr>
<td>MASQ total</td>
<td>32.28 (5.77)</td>
<td>30.03 (3.54)</td>
<td>( t(26) = 1.76, p = .09 )</td>
</tr>
<tr>
<td>Anxious</td>
<td>19.82 (4.58)</td>
<td>14.2 (3.08)</td>
<td>( t(29) = 3.98, p &lt; .001 )</td>
</tr>
<tr>
<td>Depressed</td>
<td>21.69 (8.01)</td>
<td>18.38 (6.07)</td>
<td>( t(29) = 1.29, p = .207 )</td>
</tr>
<tr>
<td>Mixed Symptoms</td>
<td>31.56 (9.70)</td>
<td>22.25 (3.42)</td>
<td>( t(19.13) = 3.59, p = .002 )</td>
</tr>
<tr>
<td>Anxious Arousal</td>
<td>22.78 (4.11)</td>
<td>18.733 (1.87)</td>
<td>( t(28) = 3.472, p = .002 )</td>
</tr>
<tr>
<td>Anhedonic Depression</td>
<td>53.46 (0.5)</td>
<td>53.18 (7.12)</td>
<td>( t(27) = .08, p = .937 )</td>
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<tr>
<td>General Distress</td>
<td>24.35 (6.90)</td>
<td>18.479 (3.57)</td>
<td>( t(23.09) = 2.87, p = .008 )</td>
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<tr>
<td>ACS total</td>
<td>25.34 (4.93)</td>
<td>30.48 (3.62)</td>
<td>( t(29) = -3.29, p = .003 )</td>
</tr>
<tr>
<td>Attentional Focusing</td>
<td>24.44 (5.49)</td>
<td>30.10 (3.61)</td>
<td>( t(29) = -3.37, p = .002 )</td>
</tr>
<tr>
<td>Attentional Shifting</td>
<td>26.25 (4.91)</td>
<td>30.87 (3.62)</td>
<td>( t(29) = -2.66, p = .013 )</td>
</tr>
</tbody>
</table>

Note. MASQ = Mood and Anxiety Symptom Questionnaire (MASQ); ACS = Attentional Control Scale. Some participants did not provide MASQ or ACS data, and were therefore excluded from those analyses. For some measures, unequal variances between age groups were controlled for by adjusting degrees of freedom.
Supplementary Table 2

Effect sizes for ratings of emotional intensity and neural activation for increase vs. view and decrease vs. view (Cohen’s dz), and for the between-subjects age difference in those two paired effects (Cohen’s d) across and within gaze directions

<table>
<thead>
<tr>
<th></th>
<th>across gaze directions</th>
<th>arousing</th>
<th>non-arousing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>increase - view</td>
<td>decrease - view</td>
<td>increase - view</td>
</tr>
<tr>
<td>ratings of emotional intensity</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>younger adults</td>
<td>0.83</td>
<td>0.21</td>
<td>0.60</td>
</tr>
<tr>
<td>older adults</td>
<td>1.64</td>
<td>0.47</td>
<td>1.10</td>
</tr>
<tr>
<td>age difference for the contrast</td>
<td>0.53</td>
<td>0.34</td>
<td>0.25</td>
</tr>
<tr>
<td>dorsal medial PFC activation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>younger adults</td>
<td>1.13</td>
<td>0.59</td>
<td>1.03</td>
</tr>
<tr>
<td>older adults</td>
<td>0.30</td>
<td>0.35</td>
<td>0.15</td>
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<tr>
<td>age difference for the contrast</td>
<td>0.37</td>
<td>0.18</td>
<td>0.34</td>
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<tr>
<td>left lateral PFC activation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>younger adults</td>
<td>1.29</td>
<td>1.04</td>
<td>1.10</td>
</tr>
<tr>
<td>older adults</td>
<td>0.41</td>
<td>0.45</td>
<td>0.28</td>
</tr>
<tr>
<td>age difference for the contrast</td>
<td>0.55</td>
<td>0.39</td>
<td>0.39</td>
</tr>
</tbody>
</table>

*Notes. Arousing = gaze directed to an emotionally relevant area of the picture, non-arousing = gaze directed away from the emotionally relevant areas of the picture.*
Supplemental Figure 1.

Dot detection results for unpleasant picture trials. Error bars represent +1 SEM.