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Supplemental Material

Results of Pre-exposure and Active Regulation Sessions

I. Pre-exposure

The ability to effectively use reappraisal to diminish negative emotion is typically revealed as a decrease in self-reported affect on Reappraise as compared to Look trials. As in prior work, this comparison showed that reappraisal was effective overall ($F(1,80)=201.41$, $p<0.01$). In addition, repeated exposure to aversive images on Reappraise and Look trials led to an overall decrease in negative affect reports over time across repetitions ($F(2,80)=6.24$, $p<0.01$; Figure S1A). The instruction type X exposure repetition (i.e. first, second or third repetition) interaction was not significant ($F(2,80)=0.45$, $p=0.64$, n.s.).

II. Active Regulation

A. Behavioral Results

The Active Regulation Session allowed verification that – as in numerous prior studies – reappraisal was effective in down-regulating negative affect. Here, three comparisons were relevant (see Figure S1B). First, we found that overall, reappraisal was effective as evidenced by lower self-reports of negative affect on Reappraise as compared to Look trials ($F(1,64=82.17$, $p<0.01$)). Second, there was a trend towards overall lower self-reports of negative affect for Repeated as compared to Single presentation trials ($F(1,64)=2.04$, $p=0.16$, n.s.). Although the main effect of number of presentations did not reach significance, planned t-tests showed that self-reported negative affect was lower overall on Repeated presentation trials than on their Single presentation counterparts ($t(16)=3.38$, $p<0.01$, two-tailed, $d=0.82$ for Reappraise trials and $t(16)=2.62$, $p<0.02$, two-

tailed, *d*=0.64 for Look Negative trials, respectively). Finally, the interaction of instruction type and number of repetitions was not significant (F(1,64)=0.94, p=0.76, n.s.). Together, these data confirm that reappraisal was effective in diminishing negative affect on both Repeated and Single presentation trials, and suggests that prior exposure to images in the Pre-exposure session on the prior day resulted in a trend towards weaker affective responses to them.

B. fMRI Results

Analyses of the fMRI data from the Active Regulation Session paralleled analyses of the behavioral data. The primary goal here was to simply verify that the neural correlates of effective reappraisal observed in prior studies also were observed here. Towards that end, we first sought to identify regions more active when using reappraisal to diminish negative emotion.

To do this we compared activity on Reappraise as compared to Look trials overall, collapsing across number of presentations, in order to define initial ROI's. Right amygdala activity was robustly attenuated during reappraisal, showing a main effect of instruction type (Reappraise < Look) in a 49 voxel cluster (peak at [24, -3, -15], FWE small volume-corrected, p<0.05, two-tailed; shown in blue and green in Figure 2A *(top)*). A main effect of number of presentations was also present in this amygdala ROI, with repeated presentations leading to lower amygdala activity overall (F(1,64)=36.12, p<0.01). The instruction type X number of presentations interaction was not significant (F(1,64)=0.50, p=0.48, n.s.). Planned t-tests indicated that amygdala activity was attenuated for Reappraise versus Look trials for both Repeated (t(16)=2.89, p<0.02, two-tailed, *d*=0.70) and Single stimuli (t(16)=2.72, p<0.02, two-tailed, *d*=0.66).

Robust vlPFC activity (BA 46) also was observed during Active Regulation for the contrast of Reappraise vs. Look trials overall in addition to recruitment of dorsomedial PFC (BA 6) and temporoparietal regions commonly activated during reappraisal (BA 40, 22; Table S1; Buhle et al., in press). Whole-brain results from this contrast ($p<0.01$, $k=47$ voxels, FWE-corrected, $p<0.05$, two-tailed) are shown in Figure S2 and Table S1.

Given its status as an *a priori* ROI, vlPFC activity was investigated further. vlPFC activity showed a main effect of instruction type (Reappraise > Look) in a 236 voxel cluster (peak at [-45, 48, 12], FWE-corrected, $p<0.05$, two-tailed; Figure 2A *(bottom)*) representing a local maximum within left inferior frontal gyrus meeting whole-brain FWE-correction (Table S1). This region also showed a main effect of number of presentations, with repeated presentation leading to greater activity overall relative to a single presentation ($F(1,64)=13.76$, $p<0.01$). The instruction X number of presentations interaction was not significant ($F(1,64)=0.10$, $p=0.76$, n.s.). A whole-brain search for the instruction type X number of presentations interaction at Active Regulation (i.e. [Repeated Reappraise Negative – Repeated Look Negative) – (Single Reappraise Negative - Single Look Negative]) did not yield FWE-corrected results in amygdala or PFC.

Manipulation Check: Correlation between behavioral regulation success and amygdala responses at Long-term Re-exposure

As a manipulation check, we sought to assess whether one's initial regulatory success for Repeated Reappraise trials predicts the durability of amygdala attenuation for

these trials at Long-term Re-exposure. To address this issue, we examined reappraisal success (i.e. drop in average negative affect ratings on Reappraise versus Look Negative trials) in each of the study phases where affect ratings were collected for Repeated trials (i.e. at Pre-Exposure, and at Active Regulation for Repeated trials). These reappraisal success variables were highly positively correlated with each other across participants ($r = 0.78$, $p<0.01$, two-tailed). Thus, a summary reappraisal success predictor was created, calculated as within-participant averages of these reappraisal success measures from each study phase. We then examined whether this reappraisal success measure was correlated with the magnitude of right amygdala activity attenuation across participants for Repeated Reappraise Negative trials relative to all other negative image conditions at Long-term Re-exposure. This correlation was significant in a right amygdala region slightly medial to our previous right amygdala overlap ROI, such that greater average reappraisal success during the experiment was correlated with greater relative attenuation of right amygdala activity for Repeated Reappraise Negative trials at Long-term Re-exposure (Figure S3; 34 voxels, peak at [12, -3, -15], FWE small volume-corrected, $p<0.05$, two-tailed; significant using robust regression, $p<0.01$, two-tailed).

References

Buhle, J. T., Silvers, J. A., Wager, T. D., Lopez, R., Onyemekwu, C., Kober, H., et al. (2014). Cognitive reappraisal of emotion: a meta-analysis of human neuroimaging studies. *Cereb Cortex, 24*(11), 2981-2990.

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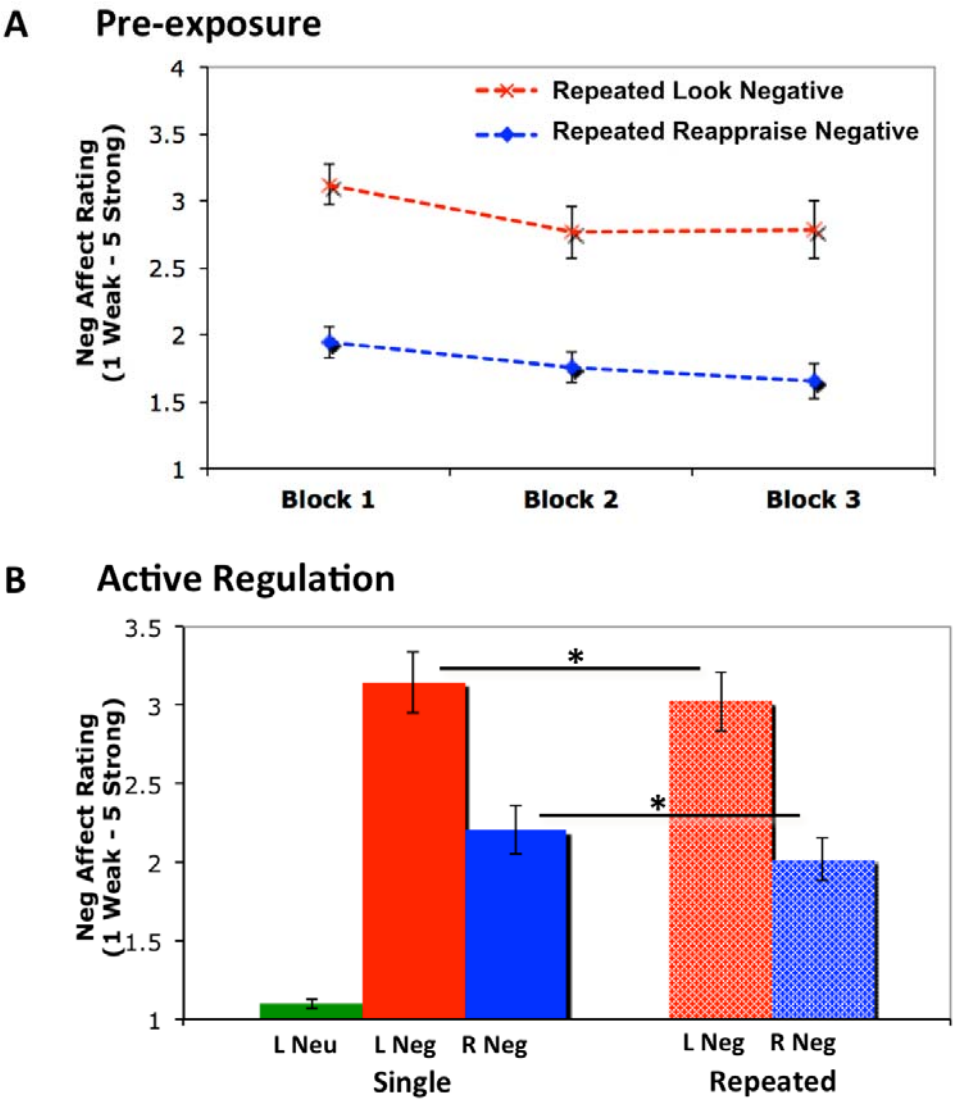

Figure S1. Behavioral results during Pre-exposure (A) and Active Regulation (B). Error bars represent ±standard error (SEM). * reflects $p<0.05$, two-tailed.

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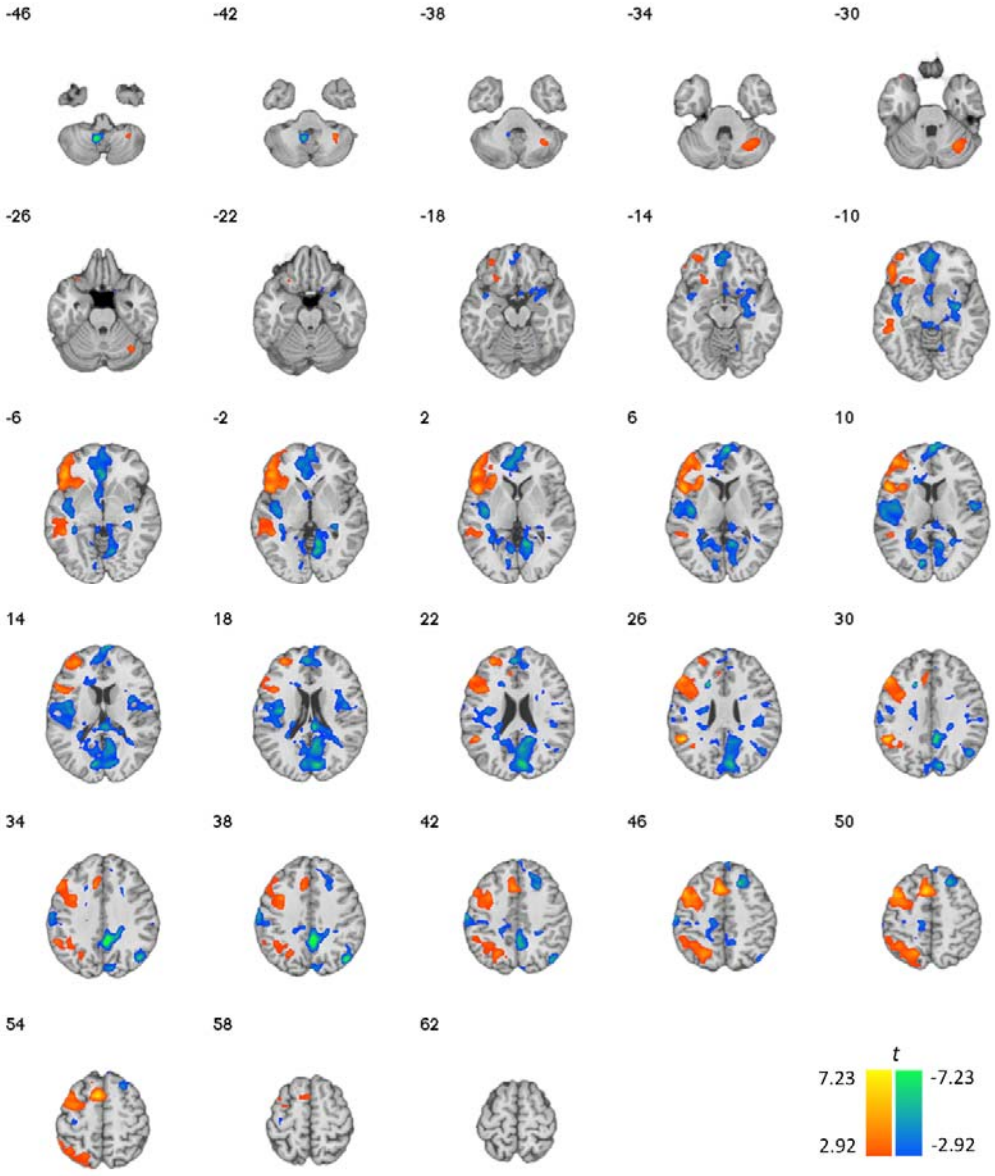

Figure S2. Axial montage of whole-brain analysis showing activity for the contrast of Reappraise Negative versus Look Negative trials during Active Regulation (collapsed across number of presentations). Thresholded at $p<0.01$, $k=47$ voxels (FWE-corrected, $p<0.05$, two-tailed).

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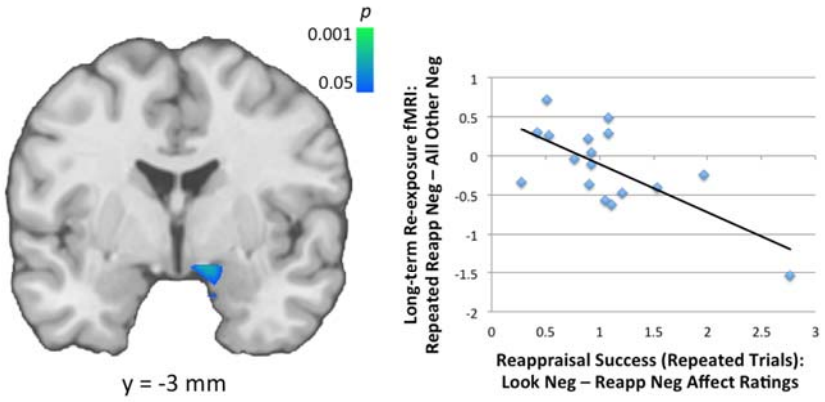

Figure S3. Scatterplot of correlation between initial regulatory success for Repeated Reappraise Negative trials and right amygdala activity during Long-term Re-exposure. Graph shows that greater average success in using reappraisal to diminish negative affect for Repeated Reappraise Negative trials predicts greater relative attenuation of right amygdala activity for these trials at Long-term Re-exposure (34 voxels, peak at [12, -3, -15], FWE small volume-corrected, $p<0.05$, two-tailed). The scatterplot is shown for illustrative purposes only.

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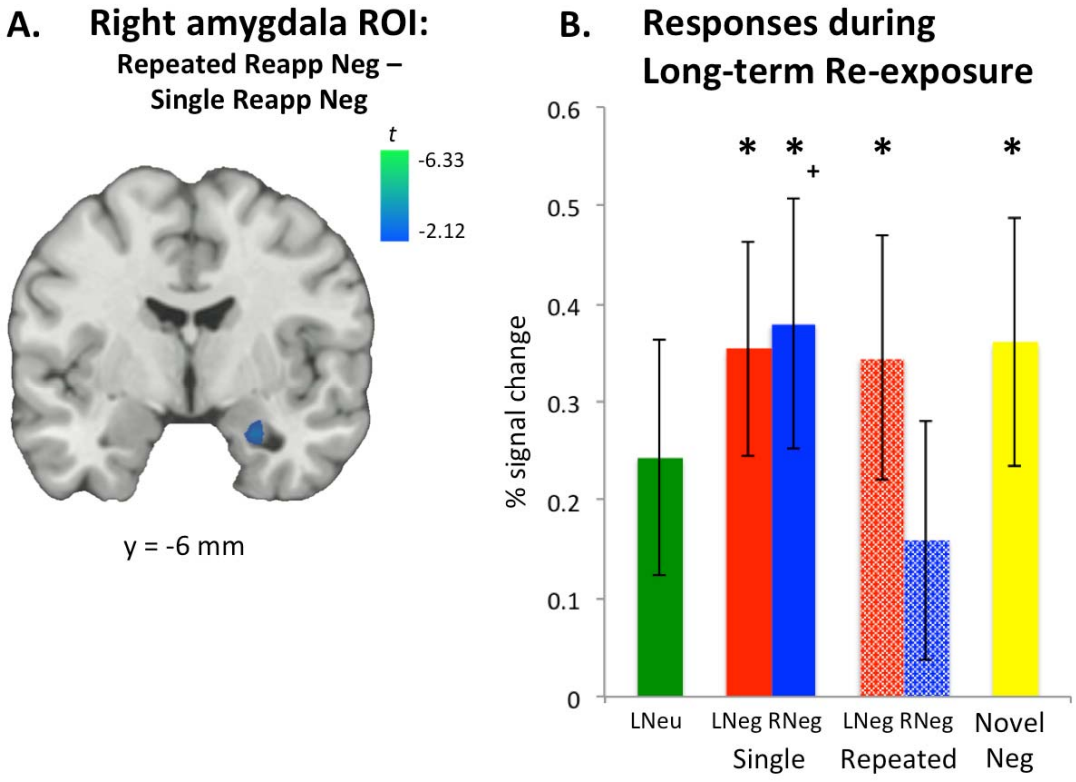

Figure S4. (A) Right amygdala ROI, defined as a contrast of Repeated Reappraise Negative versus Single Reappraise Negative trials at Long-term Re-exposure (21 voxels, peak at [24, -6, -24], FWE small volume-corrected, $p<0.05$, two-tailed). (B) Activity from this ROI at Long-term Re-exposure (* reflects a significant difference from Repeated Reappraise Negative trials, $p<0.05$, two-tailed). $*_{+}$, reflecting the comparison of Repeated Reappraise Negative versus Single Reappraise Negative trials, is non-independent of the selection criterion for the ROI and is shown for illustration of the selection criterion only. The 2 X 2 instruction type X number of presentations interaction (i.e. including Repeated Reappraise Negative, Repeated Look Negative, Single Reappraise Negative, and Single Look Negative trials) is significant in this ROI ($F(1,48)=5.22$, $p<0.03$), with activity lowest for Repeated Reappraise Negative trials.

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Error bars represent ±standard error (SEM).

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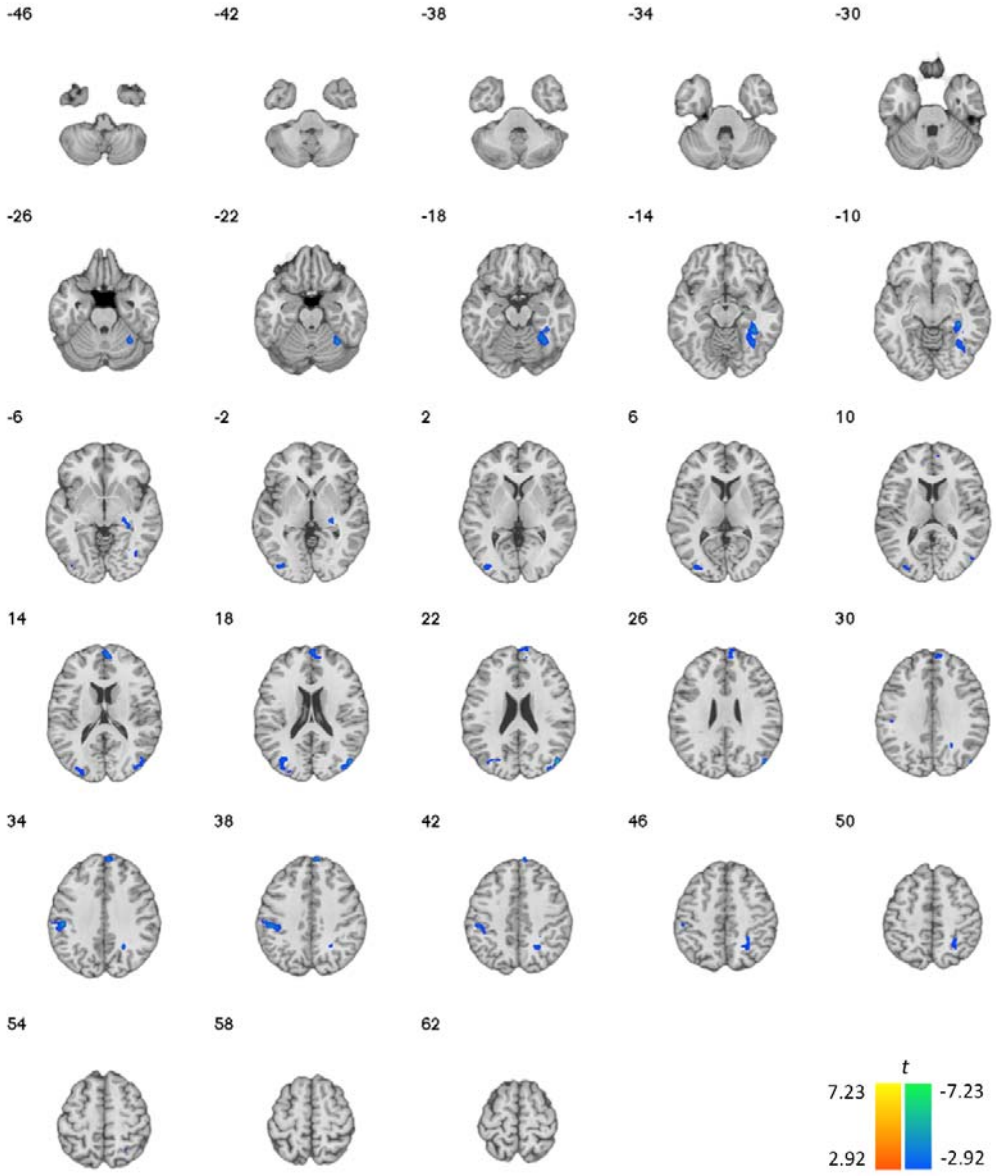

Figure S5. Axial montage of whole-brain analysis showing activity for the contrast of Repeated Reappraise Negative versus all other negative conditions at Long-term Re-exposure (i.e. Repeated Reappraise Negative – 0.25*[Repeated Look Negative + Single Reappraise Negative + Single Look Negative + Novel Negative]). Thresholded at $p<0.01$, $k=47$ voxels (FWE-corrected, $p<0.05$, two-tailed). Small volume-corrected right amygdala results for this contrast are shown in yellow and green Figure 2A *(top)* and

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Table S2.

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Reappraise Negative > Look Negative (collapsed across number of presentations) at Active Regulation

x	y	z	k	Max	Mean		Region
-51	33	3	1586	6.268	3.733	LH	Inferior Frontal Gyrus (BA's 44, 45, 46, 47)
-6	12	54	251	6.669	3.983	LH	Superior Frontal Gyrus (BA 6)
-51	-48	27	480	7.002	3.524	LH	Supramarginal Gyrus (BA 40)
-48	-42	-6	190	4.722	3.363	LH	Middle Temporal Gyrus (BA 22)
30	-51	-42	105	4.313	3.451	RH	Cerebellum
-45	48	12	236	5.595	3.341	LH	vlPFC (BA 46)^

Reappraise Negative < Look Negative (collapsed across number of presentations) at Active Regulation

x	y	z	k	Max	Mean		Region
3	-48	36	2832	-9.152	-3.813	RH	Precuneus (BA 31)
3	63	6	841	-6.644	-3.784	RH	Medial Frontal Gyrus (BA 10)
21	27	48	189	-6.414	-3.815	RH	Middle Frontal Gyrus (BA 8)
-18	21	27	84	-7.027	-3.582	LH	Cingulate Gyrus (BA 32)
-12	-24	48	94	-4.679	-3.385	LH	Cingulate Gyrus (BA 31)
-60	-18	45	155	-6.583	-3.584	LH	Postcentral Gyrus (BA 3)
54	-9	9	144	-5.230	-3.563	RH	Transverse Temporal Gyrus (BA 41)
45	-24	27	59	-4.276	-3.345	RH	Inferior Parietal Lobule (BA 40)
33	-12	-9	196	-6.382	-3.537	RH	Claustrum
-6	-54	-45	56	-7.564	-4.219	LH	Cerebellum
24	-3	-15	49	-3.825	-2.847	RH	Amygdala*

Table S1. Active Regulation results for the contrast of Reappraise Negative versus Look Negative trials (collapsed across number of presentations). Maximum and mean t-values are shown for each cluster. Coordinates are in MNI space and refer to the peak activation. Thresholded at $p<0.01$, two-tailed, k=47 voxels (FWE-corrected, $p<0.05$, two-tailed), except as noted below. ^ refers to left vlPFC local maximum within left inferior frontal gyrus meeting whole-brain FWE-correction, $p<0.05$, two-tailed, k=152 voxels (FWE-

corrected, p<0.05, two-tailed). * reflects p<0.05, FWE small volume-corrected, p<0.05, two-tailed.

Repeated Reappraise Negative < All Other Negative at Long-term Re-exposure

x	y	z	k	Max	Mean		Region
48	-78	21	52	-6.453	-3.687	RH	Middle Temporal Gyrus (BA 19)
36	-42	-15	149	-5.826	-3.556	RH	Fusiform Gyrus (BA 37)
-51	-27	36	67	-5.195	-3.506	LH	Postcentral Gyrus (BA 2)
6	54	36	76	-4.561	-3.449	RH	Superior Frontal Gyrus (BA 9)
24	-57	33	47	-4.179	-3.230	RH	Precuneus (BA 7)
-33	-75	18	67	-3.734	-3.208	LH	Middle Occipital Gyrus (BA 19)
30	-3	-21	40	-4.363	-2.861	RH	Amygdala*

Repeated Reappraise Negative > All Other Negative at Long-term Re-exposure
No significant clusters

Table S2. Contrast of Repeated Reappraise Negative trials versus all other negative conditions at Long-term Re-exposure (i.e. Repeated Reappraise Negative– 0.25*[Repeated Look Negative + Single Reappraise Negative + Single Look Negative + Novel Negative]). Maximum and mean t-values are shown for each cluster. Coordinates are in MNI space and refer to the peak activation. Thresholded at p<0.01, two-tailed, k=47 voxels (FWE-corrected, p<0.05, two-tailed), except as noted below. * reflects p<0.05, FWE small volume-corrected, p<0.05, two-tailed.