Supporting Online Material for:

Feeling bad about screwing up: Emotion regulation and action monitoring in the anterior cingulate cortex (ACC)

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This file includes:

A table showing our coding procedures of free descriptions of regulation strategies (Table S1), the average number of trials analyzed per condition (Table S2), figures s showing our manipulation check for explicit emotion regulation: subjective ratings on self-perceived arousal level (Figure S1), negative emotion (Figure S2), free descriptions of regulation strategies (Figure S3), relationships between error-related brain activity in the dorsal ACC ROI and reaction time (Figure S4), and scatter plots to show the influence of smaller numbers of averaged trials on fMRI signal change (Figure S5).

Table S1. Definitions of each emotion regulation strategy.

Category	Definition
"Cognitive Reappraisal"	involves changing the way the individual thinks about a potentially emotion-eliciting situation in order to modify its emotion impact.
"Suppression"	involves reducing emotion-expressive behavior once the individual is already in an emotional state or try to push out emotional experience.
"Attention Control"	involves working harder to focus on the cognitive task.
"Emotional Experience"	involves letting oneself to experience emotion fully.
"Problem Solving"	involves thinking about how to solve their problems in a positive way.
"Relax"	involves releasing physical tension by deep breathing or releasing muscles.
"Rumination"	involves dwelling on their negative thoughts repetitively.

Coding Procedures: In a debriefing session, participants were asked to write exactly how they tried to regulate their negative emotion after errors during each condition in the fMRI scanner. Seven categories of emotion regulation strategies in Table S1 were defined for this error-related negative emotion regulation study referring to the previous studies (e.g., John & Gross, 2004). Two of the authors independently coded those emotion regulation strategies based on the definitions shown in Table S1. The purpose of coding was to examine whether participants used more “cognitive reappraisal” as a regulation strategy than “suppression”. We report inter-rater reliability for our codings, coded frequency of each strategy along with tests of the relative frequency of suppression and reappraisal in Figure S3.

Table S2. The average number of trials analyzed per condition. The numbers of trials (Mean (SD, range)) contributed to the % signal changes estimates analyzed in each condition.

	Emotion Regulation Condition		
	Natural	Decrease	Increase
Conflict Monitoring			
X	29 (3.9, 35-17)	15 (2.6, 19-11)	14 (2.7, 19-9)
non-X	20 (4.9, 28-7)	11 (2.8, 15-6)	11 (3.2, 16-6)
Error Processing			
Current Correct	30 (7.1, 40-19)	15 (4.3, 20-7)	15 (3.4, 20-9)
Current Error	18 (10.3, 37-4)	10 (6.1, 21-2)	10 (4.9, 19-2)
Error Prevention			
Subsequent Correct	25 (10.1, 39-11)	10 (4.8, 17-2)	12 (6.2, 21-2)
Subsequent Error	23 (8.8. 39-9)	14 (4.2, 23-7)	14 (6.0, 24-4)

Table S3. Effect sizes with and without subjects who had <3 trials for each condition.

	Mean of all subjects	*Mean of all except excluded subjects*	*SD of all subjects*	*SD of all except excluded subjects*	*d1**	*d2***
Error Processing						
Natural	*0.05*	*0.02*	*0.26*	*0.19*	***0.19***	***0.11***
Decrease	*-0.13*	*-0.11*	*0.21*	*0.16*	***-0.62***	***-0.69***
Increase	*0.07*	*0.01*	*0.36*	*0.30*	***0.19***	***0.03***
Error Prevention						
Natural	*-0.01*	*-0.02*	*0.15*	*0.16*	***-0.07***	***-0.13***
Decrease	*-0.15*	*-0.14*	*0.14*	*0.14*	***-1.07***	***-1.00***
Increase	*0.07*	*0.07*	*0.17*	*0.19*	***0.41***	***0.37***

*d1 = (mean of all subjects) / (SD of all subjects), **d2 = (mean of all except excluded subjects) / (SD of all except excluded subjects)

Effect sizes computed including and excluding subjects who had <3 trials of averaged for any condition (N=1 to 3) were very similar, showing that effects are not critically different with and without these subjects. That is, effects generally did not differ by >.1, and remained within traditional categories of small (<.2), medium (.3-.5), or large (>.6). ROI data (percent change data from baseline) was used from Figure 3 (middle left) for the error processing, and from Figure 3 (lower left) for the error prevention.

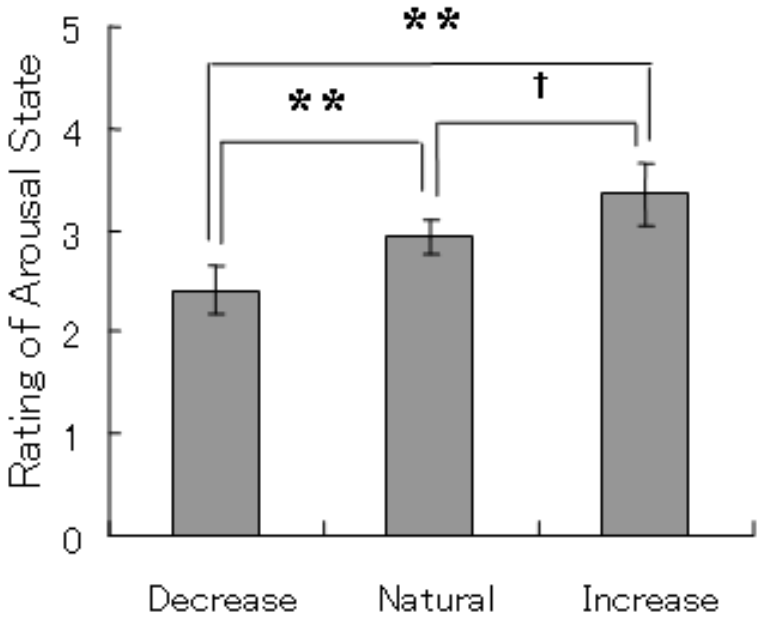


Figure S1. Self-perceived arousal level in each emotion regulation condition (**$p < .01$, $^{\dagger}p < .10$). Subjective ratings on arousal level was significantly lower in the decrease condition compared to the natural and increase conditions ($p < .01$). The difference of self-perceived arousal was not significantly different between the natural and increase conditions probably because errors could be associated with already high enough arousal in the natural condition and could be hard to increase the level of arousal more than that.

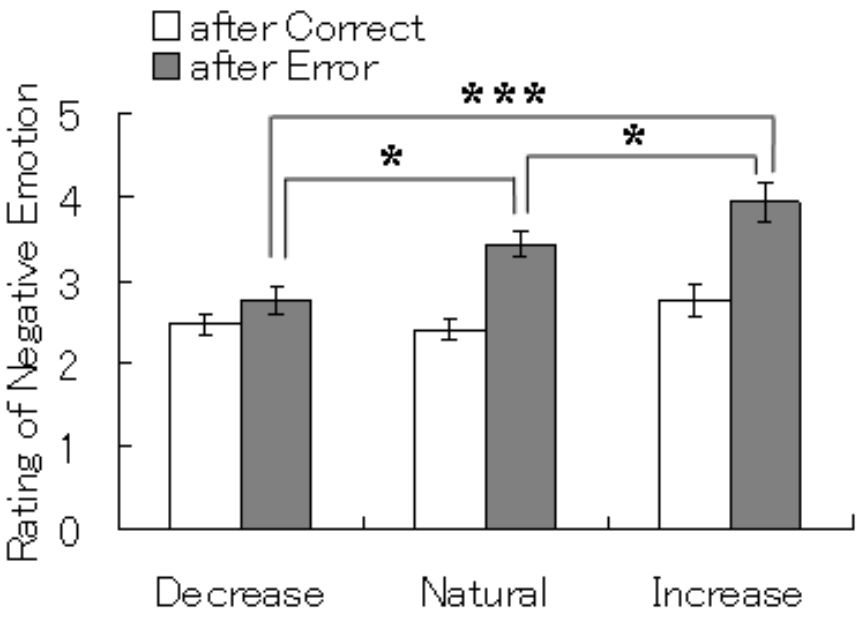


Figure S2. Self-perceived negative emotion level after error or correct responses in each emotion regulation condition (***p < .005, *p < .05). Ratings of negative emotion showed significant differences among regulation conditions after error trials but not after correct trials (F(2,32) = 4.69, p < .05, ηp^2 = .23). After error trials, participants reported higher negative emotion in the increase condition and lower in the decrease condition compared to the natural condition.

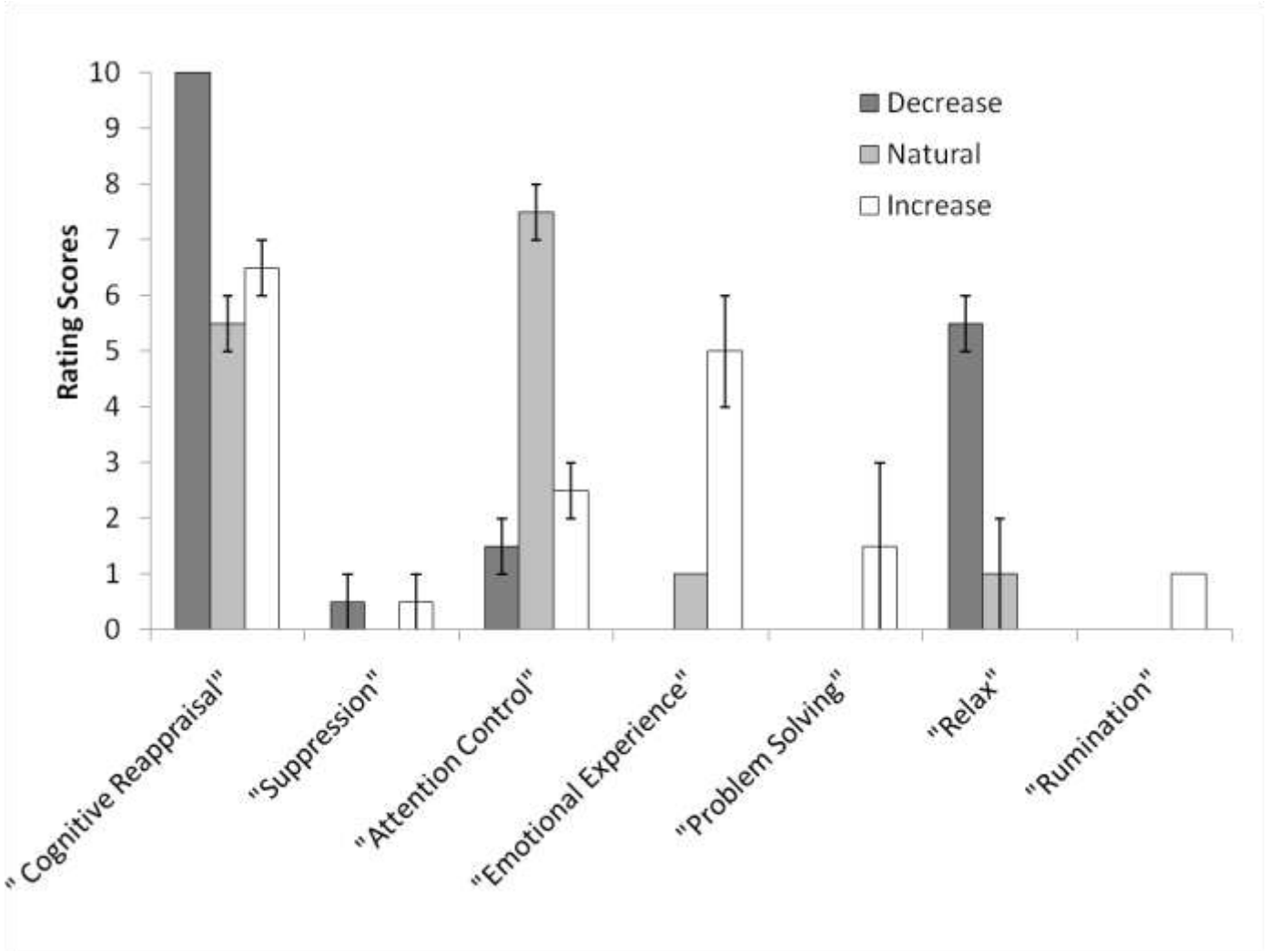


Figure S3. Coding the reported strategy applied by each participant during fMRI scans (Mean with Standard Deviation bars; See Table S1 for details and coding procedures). The purpose of coding was to examine whether participants used more "cognitive reappraisal" as a regulation strategy than "suppression". Coding of these two strategies achieved adequate agreement with kappa coefficients from .61 to 1.0 (Landis & Koch, 1977). The ratings for two independent raters completely matched on "Reappraisal" in the Decrease condition and "Suppression" in the Increase condition. (i.e., the scores in the Decrease condition were *M(SD)* = 10 (0.0) for cognitive reappraisal, and *M(SD)* = 0.5 (0.7) for

suppression; those in the Increase condition were *M(SD)* = 6.5 (0.7) for cognitive reappraisal, and *M(SD)* = 0.0 (0.0) for suppression).

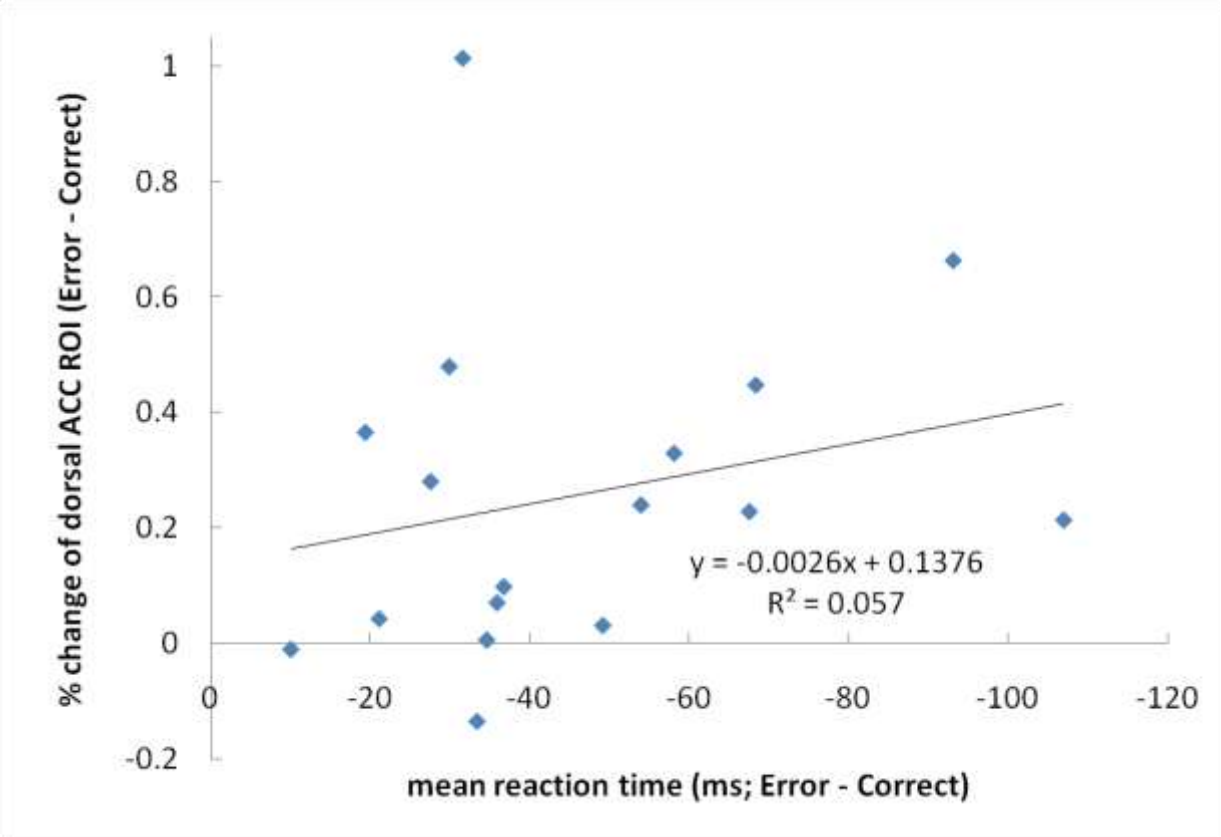
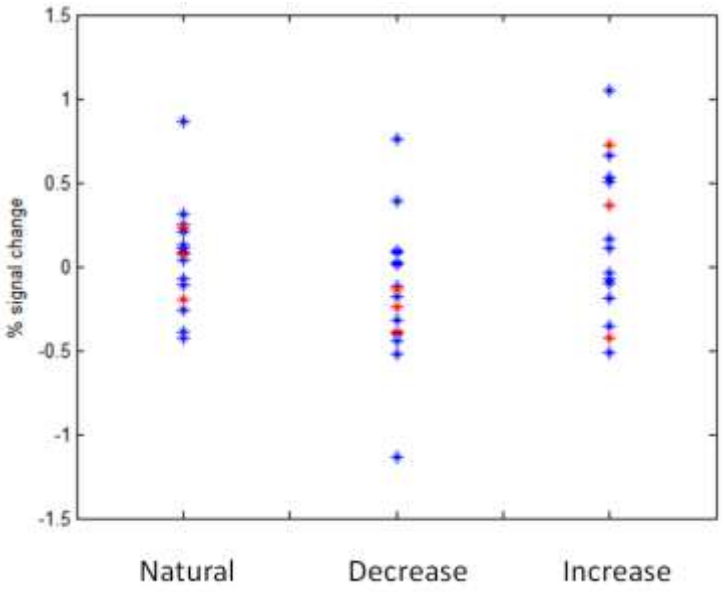


Figure S4. To investigate whether correct/error differences in brain function were associated with reaction time (RT) results, the relationship between activity in the dorsal ACC ROI associated with performance (scan 4 which was the peak activity, Error minus Correct) and the mean RT differences (Error minus Correct) are shown above. The results showed that the observed error-related brain activity was not driven by RT differences between Error and Correct trials ($r = -.24$, $p = .36$).

A.



B.

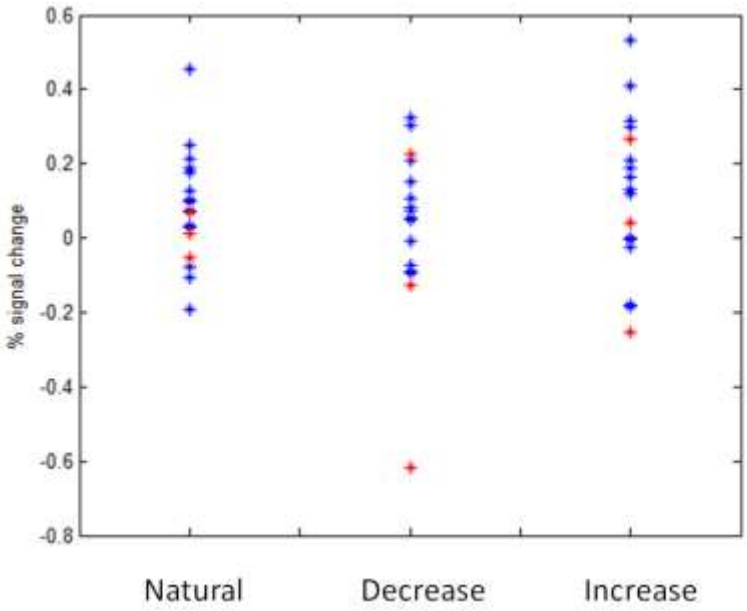


Figure S5. Scatter plots show the influence of the number of averaged trials on fMRI signal change. Examples are plotted for subsequent accuracy in the subcollosal cingulate (S5A based on data from

Figure 2, lower left in the manuscript) and for current accuracy in the dorsal ACC (S5-B based on data from Figure 3, upper left; current accuracy). Three subjects who had the smallest number of trials for each current accuracy and subsequent accuracy were marked as RED asterisk, and other subjects were marked as BLUE asterisks. . The averaged percent signal change is calculated over the scans (scan 2-7) for each condition. As shown in this figure, participants with the smallest numbers of averaged trials were not systematic outliers and did not drive the basic character of the results (highest signal for increase). .