



## Relative left frontal activity in reappraisal and suppression of negative emotion: Evidence from frontal alpha asymmetry (FAA)



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### ABSTRACT

Previous studies have shown that reappraisal (changing the way that one thinks about emotional events) is an effective strategy for regulating emotion, compared with suppression (reducing emotion-expressive behavior). In the present study, we investigated relative left frontal activity when participants were instructed to use reappraisal and suppression of negative emotion, by measuring frontal alpha asymmetry (FAA). Two electroencephalography (EEG) experiments were conducted; FAA was analyzed while 102 healthy participants (59 men, 43 women) watched negative images after being instructed to perform reappraisal (Experiment 1) and suppression (Experiment 2). Habitual use of reappraisal and suppression was also assessed using the emotion regulation questionnaire (ERQ). The results of Experiment 1 showed that relative left frontal activity was greater when instructed to use reappraisal of negative images than when normally viewing negative images. In contrast, we observed no difference between conditions of instructed suppression and normal viewing in Experiment 2. In addition, in male participants, habitual use of reappraisal was positively correlated with increased relative left frontal activity for instructed reappraisal, while habitual use of suppression did not show a significant correlation with changes in relative left frontal activity for instructed suppression. These results suggest that emotional responses to negative images might be decreased for instructed reappraisal, but not suppression. These findings support previous reports that reappraisal is an effective emotion regulation strategy, compared with suppression.

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### 1. Introduction

Emotions are regulated in various ways in everyday life. The most commonly investigated strategies for regulating emotion are cognitive reappraisal (hereafter, reappraisal) and expressive suppression (hereafter, suppression). Reappraisal refers to the act of changing the way one thinks about emotional events, while suppression refers to reducing emotion-expressive behavior (reviewed in John & Gross, 2004). A number of studies have reported that these two strategies have different effects on both psychological and physiological responses (for example, Gross, 1998; Butler et al., 2003; Goldin et al., 2008; McRae et al., 2012). For example, subjective experience of negative emotion was reported to be decreased by reappraisal, but unchanged by suppression (Gross, 1998). In addition, habitual use of reappraisal is related to positive affectivity and better psychological well-being, while habitual use

of suppression is related to negative affectivity and poorer psychological well-being (Gross and John, 2003; McRae et al., 2012). A functional magnetic resonance imaging (fMRI) study reported that responses in emotion-generative regions such as the amygdala and insular to negative stimuli were decreased by reappraisal, and increased by suppression (Goldin et al., 2008). Taken together, these results suggest that reappraisal is a more effective and healthier strategy for emotion regulation than suppression, as suggested by John & Gross (2004) and Augustine and Hemenover (2009).

Several previous electroencephalography (EEG) studies reported that automatic emotion regulation is related to greater relative left frontal activity, as measured by frontal alpha asymmetry (FAA; Jackson et al., 2003; Goodman et al., 2013). In a study by Jackson et al. (2003), participants viewed negative stimuli without performing any specific emotion regulation strategy (e.g., reappraisal or suppression). The results revealed that individuals with greater baseline relative left frontal activity (measured by the FAA) showed greater attenuation of eyeblink startle responses after viewing negative stimuli. Goodman et al. (2013) found a similar relationship between greater transient relative left frontal activity (measured by FAA) and attenuation of eyeblink startle responses under stress. Given that attenuation of eyeblink startle responses after viewing emotional stimuli reflects a decreased

*Abbreviations:* fMRI, functional magnetic resonance imaging; EEG, electroencephalography; FAA, frontal alpha asymmetry; ERP, event-related potential; ERQ, emotion regulation questionnaire; ANOVA, analysis of variance; SD, standard deviation; SE, standard error.

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emotional response (Lang et al., 1990; Van Reekum et al., 2011), the results of Jackson et al. (2003) and Goodman et al. (2013) suggest that increased relative left frontal activity (measured by both state and trait FAA) is related with decreased emotional response to negative stimuli through automatic emotion regulation. This explanation is in line with the widely accepted relationship between FAA and the approach-avoidance motivational system; greater relative left frontal activity involves mainly positive emotion related with approach motivation (e.g., joy), whereas right-sided frontal activity involves negative emotion related with avoidance motivation (e.g., fear and disgust; reviewed in Davidson, 1998; Davidson, 2004; Harmon-Jones et al., 2010).

Taken together, these findings suggest that greater relative left frontal activity may be related to decreased emotional response to negative stimuli not only through automatic emotion regulation (Jackson et al., 2003; Goodman et al., 2013), but also through emotion regulation strategies, such as reappraisal and suppression. Several recent EEG studies have investigated left frontal activity during reappraisal and suppression (Parvaz et al., 2012; Tolegenova et al., 2014; Wang et al., 2015; Papousek et al., 2016); however, the results are mixed. Parvaz et al. (2012) indicated that reappraisal of negative images and emotionally neutral images increased left frontal, but not right frontal, activity. Papousek et al. (2016) found a positive relationship between relative left frontal activity and reappraisal ability during reappraisal of anger-evoking events, as well as greater relative left frontal activity during a reappraisal task compared with the resting condition at ventrolateral prefrontal electrodes. Tolegenova et al. (2014) reported a significant relationship between emotional intelligence and EEG responses during reappraisal and suppression of fear-evoking film clips in frontal theta and gamma power, but not in frontal alpha power. These results suggest the importance of further examination of relative left frontal activity during reappraisal and suppression.

The present study aimed to investigate relative left frontal activity when participants were instructed to perform reappraisal and suppression of negative emotion, by measuring FAA. We conducted two experiments based on a protocol used in a recent event-related potential (ERP) study by Moser et al. (2014), which found that instructing participants to perform reappraisal decreased emotional arousal responses to negative images. In Experiment 1, we measured FAA while healthy young participants watched negative images after being instructed to perform reappraisal and observation. In Experiment 2, we measured the FAA while the same participants viewed negative images after being instructed to perform suppression and observation. We hypothesized that relative left frontal activity would be greater while performing reappraisal, compared with observation (Experiment 1) and that relative left frontal activity would not differ between suppression and observation (Experiment 2). This hypothesis is in accord with previous findings suggesting that reappraisal is a more effective emotion regulation strategy for decreasing emotional responses to negative stimuli compared with suppression (Gross, 1998; Butler et al., 2003; Goldin et al., 2008; McRae et al., 2012; McRae et al., 2012).

Additionally, the present study focused on the relationship between relative left frontal activity and habitual use of emotion regulation (measured with the emotion regulation questionnaire, ERQ, Gross and John, 2003). Several previous studies reported that habitual use of reappraisal affects emotional responses during reappraisal (Drabant et al., 2009; Grecucci et al., 2013; Moser et al., 2014). For instance, an fMRI study by Drabant et al. (2009) showed that the habitual use of reappraisal was positively correlated with decreased activation in emotion-generative regions such as the amygdala, suggesting a relationship between the habitual use of reappraisal and effective emotion regulation. Thus, in Experiment 1 of the present study, we hypothesized that individuals exhibiting greater habitual use of reappraisal would show a greater increase in relative left frontal activity when instructed to perform reappraisal than those with low habitual use of reappraisal. In contrast, there have been few studies of the relationship between the habitual use of suppression and emotional responses to

negative stimuli. Meyer et al. (2012) showed that a decreased subjective experience of emotional arousal to negative stimuli was related to habitual use of reappraisal, but not habitual use of suppression. This suggests that habitual use of suppression might be unrelated to emotion regulation responses. Based on this finding, in Experiment 2 of the present study, we hypothesized that there would be no relationship between the habitual use of suppression and relative left frontal activity changes when participants were instructed to perform suppression.

## 2. Methods

### 2.1. Participants

A total of 111 Japanese undergraduate and graduate students (62 men, 49 women; age range: 19–25 years; all right-handed) participated in Experiment 1 and Experiment 2.<sup>1</sup> Participants had normal or corrected-to-normal vision and were not taking any prescription medications. EEG quality was poor for nine participants, leaving 102 individuals (59 men, 43 women) for the final analysis. Participants provided written informed consent before participation, after receiving a brief explanation of the study.<sup>2</sup> The study protocols were approved by the ethics committee of Kyushu University, Japan.

### 2.2. Habitual use of emotion regulation

Participants filled out the Japanese version (Yoshizu et al., 2013) of the ERQ (Gross and John, 2003). The ERQ contains 6 items for the reappraisal scale (e.g., “I control my emotions by changing the way I think about the situation I'm in”) and 4 items for the suppression scale (e.g., “I control my emotions by not expressing them”). Participants rated on a Likert-scale from 1 (“does not describe me well”) to 7 (“describes me very well”). Internal consistency (Cronbach's alpha) was 0.686 for ERQ-reappraisal and 0.753 for ERQ-suppression.

### 2.3. Stimuli

In Experiment 1, 60 images (30 neutral and 30 negative) were selected from the International Affective Picture System (IAPS; Lang et al., 2008). The neutral images included scenes such as a man with an emotionally neutral expression, or basic objects such as a book or a clock. Because the neutral images were included as a filler to prevent possible habituation, as in Moser et al. (2014), the responses to neutral images were not analyzed. The negative images included scenes such as those depicting violence between people, an injured animal, or an airplane accident. Normative ratings for the IAPS (Lang et al., 2008) indicated that the negative images we chose were more unpleasant and more arousing than the neutral ones (valence rating: 4.97 for neutral images, 2.33 for negative images; arousal rating: 2.98 for neutral images, 6.27 for negative images). The specific IAPS picture identification numbers are presented in the Appendix A. The images used in Experiment 1 were the same as the images used in Moser et al. (2014).

In Experiment 2, a different set of 60 images (30 neutral and 30 negative) were selected from the IAPS (Lang et al., 2008), to prevent possible habituation to the images presented in Experiment 1. Normative ratings for the IAPS (Lang et al., 2008) were as follows: valence rating: 5.05 for neutral images, 2.38 for negative images; arousal rating: 3.24 for neutral images, 6.20 for negative images. An independent *t*-test revealed no significant differences in the normative valence or arousal ratings between the images used in Experiment 1 and Experiment 2

<sup>1</sup> Three female participants participated only in Experiment 1. They were excluded from the final analysis, enabling comparison between results of Experiment 1 and Experiment 2.

<sup>2</sup> To assess personality characteristics of participants, we also asked participants to complete the short Japanese version of the Big Five scale (Namikawa et al., 2012), which was developed based on an adjective checklist scale (Piedmont et al., 1991). For brevity, the results of the Big Five scale are not reported here.

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