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Appraisal frames of pleasant and unpleasant pictures alter emotional responses as reflected in self-report and facial electromyographic activity☆

Lingdan Wu [a,*], Markus H. Winkler [a], Marta Andreatta [a], Greg Hajcak [b], Paul Pauli [a,*]

[a] Department of Psychology (Biological Psychology, Clinical Psychology and Psychotherapy), University of Würzburg, Germany
[b] Department of Psychology, Stony Brook University, USA

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ABSTRACT

Emotional pictures elicit responses across experiential, behavioral and physiological systems. The magnitude of these responses can be modulated by altering one's interpretation of emotional stimuli. Previous studies have indicated that appraisal frames affect subsequent interpretations of upcoming stimuli so as to alter self-reported emotions, ERP activity and autonomic responses. No studies to date have examined the effect of appraisal frames on expressive behaviors as measured by facial EMG. This study aims to test the hypothesis that appraisal frames can alter both emotional experience and facial expression and attempts to examine their effect on the temporal unfolding of facial expressions. Participants ($N = 20$) were exposed to 125 pairs of appraisal frames (neutral or negative/positive) followed by neutral, unpleasant, or pleasant pictures reflecting five conditions: unpleasant-negative, unpleasant-neutral, pleasant-positive, pleasant-neutral and neutral-neutral. Results indicate that the unpleasant-negative compared to the unpleasant-neutral condition led to greater self-reported unpleasantness and arousal, as well as greater corrugator activity, and the pleasant-positive compared to the pleasant-neutral condition led to greater self-reported pleasantness and zygomaticus activity; modulation of facial responses became evident 0.5–1.0 s after stimulus onset. These results suggest that appraisal frames effectively alter both emotional experience and facial expressions.

1. Introduction

Emotions can be considered as dispositions to action (Lang, 1995) that involve responses across physiological, behavioral and experiential systems (Dolan, 2002). The magnitude of these responses depends on how one interprets the meaning of emotional stimuli (Lazarus et al., 1965; Gross, 1998, 2007). These interpretations may be manipulated retrospectively and prospectively. In the emotion regulation literature, the retrospective manipulation of interpretations such as reappraisal (i.e., the re-interpretation of emotional stimuli in a new way after the initial appraisal process) has received considerable attention (e.g., Hajcak and Nieuwenhuis, 2006; Dan-Glauser and Gross, 2011; Gross, 2007; Moser et al., 2010; Ochsner and Gross, 2008; Ray et al., 2010; Urry, 2009). However, this has not been the case for prospective manipulations of interpretative processes as provided by appraisal frames (i.e., orienting narratives that influence subsequent interpretations of emotional stimuli) (Lazarus et al., 1965). Therefore, this study aims to investigate whether and how appraisal frames of picture stimuli affect emotional responses as reflected in ratings of valence and arousal and facial expressions.

Among the multiple systems of emotional responses, facial expressions are the most natural and the most normal way to communicate emotions and are hypothesized to play a key role in generating emotional experience as suggested by the facial feedback hypothesis (Buck, 1980), which can be traced back to the seminal work of William James (James, 1884). Accordingly, alterations of facial expression should be considered as one major outcome of emotion regulation. Whereas some previous studies have noted the effects of appraisal frames on emotional experience (Gross and D'Ambrosio, 2004), autonomic responses (e.g., skin conductance and heart rate) (Lazarus et al., 1965), and event-related potentials (ERP) (Foti and Hajcak, 2008; MacNamara et al., 2011), few studies to date have examined the effects of appraisal frames on facial expression, and even fewer studies have combined measures of facial expression with other measures (e.g., self-report). To fill in the gap, the present study attempts to investigate the effect of appraisal frames on experienced emotion and facial expressions as measured by facial electromyography (EMG), which is an effective way of detecting dynamic changes in muscular activity.

Previous studies of appraisal frames have focused exclusively on regulation of negative emotions (Lazarus et al., 1965; Gross and

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* Corresponding authors at: Department of Psychology, University of Würzburg, Marcusstraße 9-11, 97070, Würzburg, Germany. Tel.: +49 931 31 86907; fax: +49 931 31 2733.
E-mail addresses: lingdan.wu@uni-wuerzburg.de (L. Wu), pauli@psychologie.uni-wuerzburg.de (P. Pauli).

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D'Ambrosio, 2004; Foti and Hajcak, 2008; Dennis and Hajcak, 2009; MacNamara et al., 2009); therefore, it is unclear if this cognitive strategy alters positive emotions too. Prior work has indicated that the experience of positive emotion is highly correlated with proper functioning in cognitive, affective and social domains (Fredrickson, 2001; Fredrickson et al., 2008). Furthermore, maladaptive positive emotional responses have been associated with psychological disorders like substance abuse (Winkler et al., 2011; Geier et al., 2000), depression (Aldao et al., 2010) and ADHD (Conzelmann et al., 2010; Conzelmann et al., 2011). Hence, further studies that investigate the impact of appraisal frames on emotional responses to pleasant stimuli would not only extend prior work, but may also have important implications for cognitive psychotherapy.

The present study aims to determine whether appraisal frames can alter both emotional experience and facial expression during the subsequent presentation of pleasant and unpleasant stimuli. We adopted a paradigm in which prior to each emotional picture, participants were provided with an auditory appraisal frame (i.e., either an emotional or neutral narrative that describes the content of an upcoming picture) to influence subsequent appraisal processes (Foti and Hajcak, 2008). We simultaneously measured self-reports of valence (i.e., degree of unpleasantness-pleasantness) and arousal (i.e., degree of excitability) as well as facial EMG activity recorded over the corrugator supercilii (i.e., frowning muscle) and the zygomaticus major muscle (i.e., smiling muscle), which have been found to be sensitive to unpleasant and pleasant stimuli, respectively (Cacioppo et al., 1986; Lang et al., 1993; Dimberg, 1990; Witvliet and Vrana, 1995).

It has been demonstrated previously that emotional pictures affect facial EMG within the first second after picture onset (Dimberg and Thunberg, 1998; Weyers et al., 2006), however, it is not yet known at which point the facial EMG response may be modulated by preceding appraisal frames. Therefore, an additional aim of this study is to explore the temporal dynamic of facial EMG as a function of appraisal frames.

We predicted that both emotional experience (i.e., self reports) and emotional expression (i.e., facial EMG activity) would be modulated by appraisal frames. In particular, we hypothesized that (1) unpleasant stimuli preceded by negative narratives would be rated as more unpleasant and arousing than unpleasant pictures preceded by neutral narratives, and would increase corrugator activity; (2) pleasant stimuli preceded by positive narratives would be rated as more pleasant and arousing than pleasant pictures preceded by neutral narratives, and would increase zygomaticus activity. We also expected that the appraisal frame would affect emotional facial responses within the first second after picture onset.

2. Method

2.1. Participants

A total of 24 right-hand individuals (15 females) were recruited through Internet advertisements. The average age was 25.2 ± 5.9 years (range: 17–41 years). All participants reported normal hearing and normal or corrected to normal visual acuity. Most participants were students from the University of Würzburg receiving either money (6 Euro/h) or course credit. All participants were screened with a demographic questionnaire before testing. Exclusion criteria included use of illicit drugs or a history of psychiatric or neurological disorders. According to these criteria, four participants were excluded from data analysis because of illegal drug use.

2.2. Materials

125 pictures (including 25 neutral scenes, 50 pleasant scenes and 50 unpleasant scenes) from the International Affective Picture System (IAPS; Lang et al., 2005) were used.[1] These pictures were representative of most of the stimuli included in the picture system and depicted events like accidents, mutilations, household objects, people, foods, sports, etc. Each picture was presented with a picture size of 600 pixels in height and 800 pixels in width at a viewing distance of 60 cm using Presentation software (Neurobehavioral Systems, Albany, CA).

Auditory narratives were recorded in advance including 125 neutral narratives, one for each picture (e.g., “This bus travels a route from Boston to Atlanta” for a neutral picture, “This is a poster for an upcoming action movie” for an unpleasant picture, and “These chimpanzees were trained to open their mouth” for a pleasant picture), 50 negative narratives for the unpleasant pictures (e.g., “This is a serial killer who has murdered 6 people”) and 50 positive narratives for the pleasant pictures (e.g., “These happy chimpanzees are laughing”).[2] The auditory narratives were presented binaurally via speakers with a volume of 68 dB.

Self-Assessment Manikins (SAM; Lang, 1980; Bradley and Lang, 1994) were used to measure stimulus evoked valence and arousal. The SAM is a non-verbal instrument, and consists of five graphic figures representing nine-level ratings for both valence (1 = highly unpleasant, 5 = neutral, 9 = highly pleasant) and arousal (1 = low arousal, 9 = high arousal).

2.3. Procedure and apparatus

After reading the instructions for the experiment and signing a written consent, participants were seated in a comfortable chair in a sound attenuated and dimly lit room. Then, the facial EMG sensors were attached. To decrease demand effects, participants were informed that skin conductance was measured during picture viewing. Any statements relevant to “emotion regulation” and “facial expression” were not mentioned. Three initial practice trials were given to explain the procedure. Next, the experimental session started, consisting of 125 trials, with 25 trials for each of the five experimental conditions: neutral pictures, unpleasant pictures or pleasant pictures preceded by neutral appraisal frames, and negative or positive pictures preceded by negative or positive appraisal frames, respectively (i.e., neutral-neutral, unpleasant-neutral, pleasant-neutral, unpleasant-negative and pleasant-positive).

Each trial started with a white fixation cross presented on a black screen for a period randomly ranging between 4 and 5 s. The fixation cross turned to blue 1 s before the onset of the auditory narratives, which could last from 2 to 4 s. Half of the pleasant pictures were preceded by positive narratives (pleasant-positive condition) and half of the unpleasant pictures were preceded by negative narratives (unpleasant-negative condition). The other halves of the emotional pictures were preceded by neutral narratives (pleasant-neutral condition and unpleasant-neutral condition). All of the neutral pictures were preceded by neutral narratives (neutral-neutral condition). Following each narrative, there was a 1 s delay and then the corresponding picture was presented for 4 s. At the offset of each picture, the SAM scales appeared on the screen and participants rated how they felt during picture presentation. The trials were pseudorandomized so that no more than three trials from the same condition were presented

[1] The three picture categories differed from each other regarding normative valence (M = 5.05, SD = 1.21, for neutral pictures; M = 2.82, SD = 1.64, for unpleasant pictures; M = 7.28, SD = 0.48, for pleasant pictures) and arousal (M = 2.91, SD = 1.93, for neutral pictures; M = 5.71, SD = 2.16, for unpleasant pictures; M = 5.71, SD = 2.28, for pleasant pictures).

[2] A list of the pictures and corresponding narratives is provided in the appendix; neutral and unpleasant pictures with corresponding narratives are selected from the study done by Foti and Hajcak (2008). Previous studies have indicated that those negative narratives preceding unpleasant pictures evoked greater self-reported unpleasantness and arousal, as well as greater electrocortical response than neutral narratives (Foti and Hajcak, 2008; Dennis and Hajcak, 2009). In the present study, all narratives were prepared in English and then translated into German since all participants were native German speakers.

successively. There were breaks after every 25 trials. The whole experimental session lasted about 40 min.

2.4. Psychophysiological data recording

Facial electromyographic (EMG) activity was measured above the corrugator and zygomaticus muscles. Two pairs of 4-mm Ag/AgCl electrodes were placed over the left eye (corrugator) and left cheek (zygomaticus) according to guidelines provided by Fridlund and Cacioppo (1986). A reference electrode was placed on the forehead and a ground electrode on left mastoid. The usage of an additional reference electrode was determined by the type of amplifier that uses one common reference for each recording channel (two channels for each muscle). During off-line analysis the electrodes were re-referenced to obtain bipolar recordings. Before electrode placement, sites were swabbed with an alcohol prep pad and then gently abraded using a skin preparation paste. Impedance was kept below 10 kΩ. EMG activity was acquired continuously at 1000 Hz with a V-Amp 16 amplifier (Brain Products Inc.).

2.5. Data Reduction

Off-line analyses of the EMG activity were conducted with Brain Vision Analyzer Software (Version 2.0, Brain Products Inc.). The raw signal was filtered with a band-pass filter from 30 Hz to 500 Hz and a 50 Hz notch filter. Subsequently the data were rectified and smoothed using a 125 ms moving average filter. Trials with an EMG activity above 8 μV or below −8 μV during the baseline (mean EMG activity over 1000 ms preceding picture onset) and above 30 μV or below −30 μV during picture presentation were excluded. Before statistical analysis, EMG activity was measured as the difference between the mean activity during the 4 sec picture period and the 1 sec baseline.

Self-reports and EMG activity were collapsed over the 25 trials for each condition per participant. Difference scores were calculated by subtracting data scores of the neutral condition (i.e., neutral narratives preceding neutral pictures) from each condition and further analyzed.

2.6. Statistical analyses

The difference scores were submitted to repeated analyses of variance (ANOVA) with picture valence (pleasant, unpleasant) and appraisal frame (neutral, emotion consistent) as within-subject factors. Paired t tests were conducted to further examine significant effects. For corrugator and zygomaticus activity, however, we first performed a priori tests based on the following specific hypotheses: for corrugator activity we expected enhanced activity in the unpleasant-negative compared to the unpleasant-neutral condition; for zygomaticus activity we expected enhanced activity in the pleasant-positive compared to the pleasant-neutral condition. We did not expect effects of negative and positive emotions and their regulation on zygomaticus and corrugator activity, respectively, and although this null hypothesis cannot be tested we exploratively performed t-tests comparing these conditions.

To further investigate the time points during which appraisal frames modulate facial expression, continuous recordings of facial EMG activity were segmented into eight epochs of 0.5 s each (see Dan-Glauser and Gross, 2011, for a similar segmentation when investigating temporal dynamics of emotion regulation). Corrugator supercilii activity and zygomaticus major activity were then subjected to separate repeated analyses of variance (ANOVA) with Condition (unpleasant-negative, unpleasant-neutral, pleasant-positive, and pleasant-neutral) and Time as within-subject factors. Paired t tests were conducted to further examine main effects.

For all analyses the alpha-level was set at .05. The Greenhouse–Geisser correction was applied when the assumption of sphericity was violated. The uncorrected degrees of freedom and effect sizes (partial eta-squared) are reported.

3. Results

Mean changes in self-report and EMG activity depending on emotion conditions are depicted in Figs. 1 and 2, respectively.

3.1. Effect of appraisal frame on self-reported valence and arousal

3.1.1. Self-reported valence

The ANOVA revealed main effects of picture valence ($F(1, 19) = 151.42$, $p < .01$, partial $\eta^2 = .89$) and appraisal frame ($F(1, 19) = 6.69$, $p < .05$, partial $\eta^2 = .26$), and an interaction effect of picture valence by appraisal frame ($F(1, 19) = 64.46$, $p < .01$, partial $\eta^2 = .77$). The unpleasant-negative condition was rated as more negative than the unpleasant-neutral condition ($t(19) = 7.75$, $p < .01$). Moreover, the pleasant-positive condition was rated as more pleasant than the pleasant-neutral condition ($t(19) = -4.07$, $p < .01$).

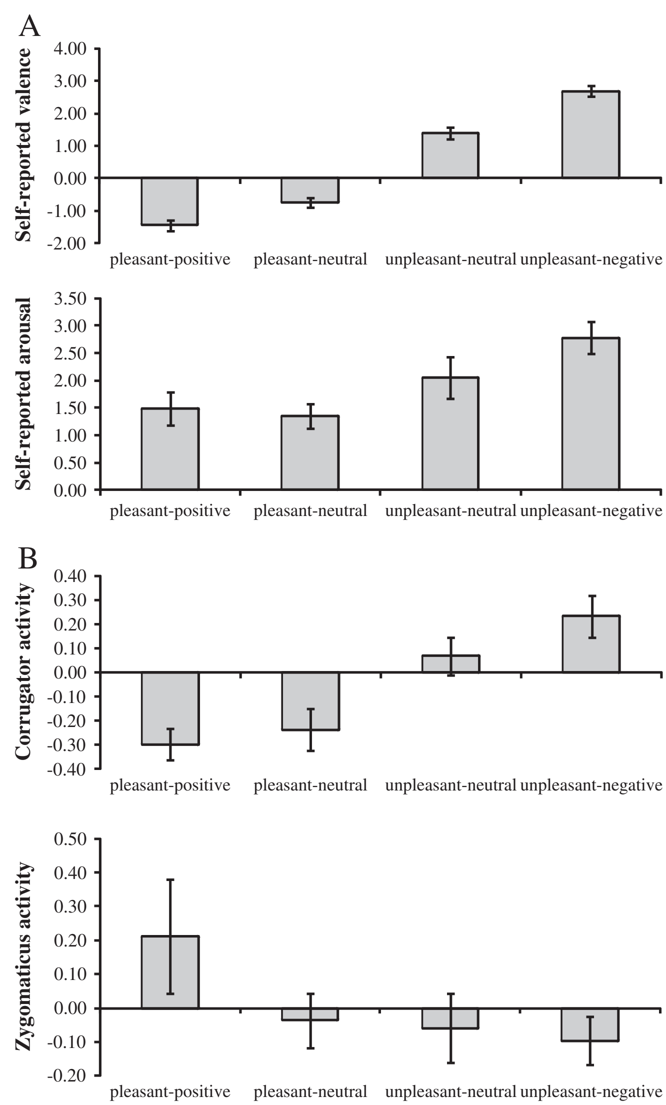

Fig. 1. A. Effect of appraisal frames on ratings of valence and arousal. Depicted are changes in self-reported valence (top) and self-reported arousal (bottom) as a function of appraisal frame. B. Effect of appraisal frames on facial EMG activity. Depicted are changes in corrugator activity (top) and zygomaticus activity (bottom) as a function of appraisal frame. Each bar represents the difference score between one of the four conditions (unpleasant-neutral, unpleasant-negative, pleasant-neutral, and pleasant-positive) and the neutral condition. Error bars represent standard error of the mean (SEM).

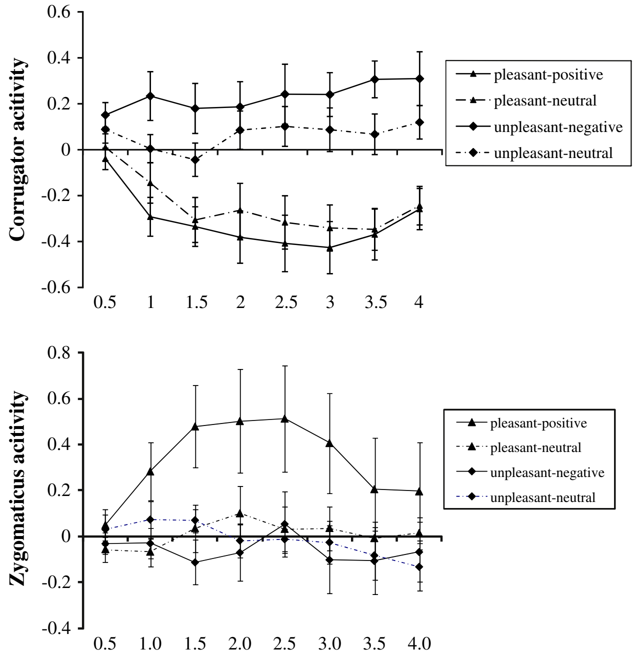

Fig. 2. Dynamic changes in corrugator (top) and zygomaticus (bottom) activity depending on up- or down- regulations. Each point represents the average difference score over a 0.5 s time epoch between one of the four conditions (unpleasant-neutral, unpleasant-negative, pleasant-neutral, and pleasant-positive) and the neutral condition. Error bars represent standard error of the mean (SEM).

3.1.2. Self-reported arousal

The ANOVA revealed main effects of picture valence ($F(1, 19) = 28.13$, $p < .01$, partial $\eta^2 = .60$) and appraisal frame ($F(1, 19) = 9.34$, $p < .01$, partial $\eta^2 = .33$), and an interaction effect of picture valence by appraisal frame ($F(1, 19) = 4.70$, $p < .01$, partial $\eta^2 = .20$). The unpleasant-negative condition was rated as more arousing than the unpleasant-neutral condition ($t(19) = 1.86$, $p < .01$). However, there was no reliable difference between pleasant-positive and pleasant-neutral conditions ($t(19) = 0.58$, $p = .57$).

3.2. Effect of appraisal frame on facial EMG activity

3.2.1. Corrugator activity

The a priori *t* tests showed that corrugator activity was higher in the unpleasant-negative condition compared to the unpleasant-neutral condition ($t(19) = 1.86$, $p < .05$). The exploratory comparison of the corrugator activity between the pleasant-positive and pleasant-neutral conditions failed to reach statistical significance ($t(19) = -0.72$, $p = .24$). The ANOVA revealed a significant main effect of picture valence ($F(1, 19) = 28.86$, $p < .01$, partial $\eta^2 = .60$), but no main effect of appraisal frame ($F(1, 19) = 0.75$, $p = .40$, partial $\eta^2 = .04$). The interaction effect of picture valence by appraisal frame reached marginal significance ($F(1, 19) = 3.34$, $p = .08$, partial $\eta^2 = .15$).

3.2.2. Zygomaticus activity

The a priori *t* tests revealed that zygomaticus activity was larger in the pleasant-positive condition compared to the pleasant-neutral condition ($t(19) = 1.82$, $p < .05$). The exploratory *t* test comparing the unpleasant-negative and the unpleasant-neutral conditions was not significant ($t(19) = -0.35$, $p = .37$). The ANOVA revealed neither significant main effects (picture valence: $F(1, 19) = 2.97$, $p = .10$, partial $\eta^2 = .14$; appraisal frame: $F(1, 19) = 1.68$, $p = .21$, partial $\eta^2 = .08$) nor a significant interaction of picture valence by appraisal frame ($F(1, 19) = 2.47$, $p < .13$, partial $\eta^2 = .12$).

3.3. Temporal dynamics of facial EMG as a function of appraisal frame

Dynamic changes in EMG activity depending on experimental conditions are depicted in Fig. 2.

For the corrugator supercilii activity, significant effects of Condition ($F(3, 57) = 14.86$, $p < .01$, partial $\eta^2 = .44$) and a Condition by Time interaction ($F(21, 399) = 3.91$, $p < .01$, partial $\eta^2 = .17$) were found. *t* Tests showed that from the second time epoch (i.e., 0.5–1 s), corrugator activity in the unpleasant-negative condition was greater than in the unpleasant-neutral condition ($t(19) = 2.54$, $p < .05$). The condition effect maintained until 1.5–2 s when corrugator activity in the unpleasant-neutral condition increased to a level comparable to that of the unpleasant-negative condition ($t(19) = -0.97$, $p = .35$).

For the zygomaticus major activity, again significant effects of Condition ($F(3, 57) = 3.65$, $p < .05$, partial $\eta^2 = .16$) and a Condition by Time interaction ($F(21, 399) = 2.49$, $p < .05$, partial $\eta^2 = .12$) were found. *t* Tests showed that from 0.5 to 1 s, zygomaticus activity in the pleasant-positive condition was greater than in the pleasant-neutral condition ($t(19) = 2.96$, $p < .01$). This difference lasted until 3.0–3.5 s when zygomaticus activity in the pleasant-positive condition decreased to a level comparable to that of the pleasant-neutral condition ($t(19) = -0.97$, $p = .35$).

4. Discussion

The findings of this study support our expectation that both emotional experience (i.e., self-reports) and facial expression (i.e., EMG activity) triggered by pleasant or unpleasant picture stimuli can be altered by appraisal frames.

First, this study extends the emotion regulation literature by showing that compared to neutral appraisal frames, negative appraisal frames preceding unpleasant pictures increased subjective unpleasantness, subjective arousal and corrugator activity. In other words, the appraisal frame preceding unpleasant events may effectively modulate both emotional experience and facial emotional expression. Moreover, this modulation occurs very fast (0.5–1.0 s after the onset of the unpleasant picture), as revealed by the temporal analysis of corrugator activity. These results support previous studies that have indicated an effect of appraisal frame on emotional experience and/or electrocortical responses (Lazarus et al., 1965; Gross and D'Ambrosio, 2004; Foti and Hajcak, 2008; Dennis and Hajcak, 2009; MacNamara et al., 2009).

Facial expression is unique in that it is a physiological–behavioral response and has important implications for social interaction. To our knowledge, this is the first study investigating the effects of preceding appraisal frames on facial EMG activity. Yet, our results are consistent with those of a previous study on reappraisal revealing greater experienced unpleasantness and enhanced corrugator activity when unpleasant pictures were *re*-appraised in a more negative way (Ray et al., 2010). However, our results are inconsistent with other work, which failed to find a reliable effect of reappraisal on facial expression (e.g., Urry, 2009). The reason for this inconsistency might lie in procedural differences as participants in studies on reappraisal are commonly asked to self-generate narratives following instructions (such as 'enhance' or 'decrease') to regulate their initial emotional response. This emotion regulation procedure is probably explicit, effortful and rule-based (Gyurak et al., 2011). Accordingly, variations in the ability of participants to reappraise specific emotional stimuli may lead to variations in the amount of effort invested in the emotion regulation task, thus producing unstable effects (Ray et al., 2010). Compared to reappraisal, emotion regulation in the present study may be relatively implicit, prospective and automatic; participants merely listened carefully to auditory narratives and viewed the picture stimuli. Auditory narratives preceding picture stimuli may automatically impact subsequent appraisal processes without conscious effort or monitoring, thereby controlling for task difficulty and effort involved in the task (Foti and Hajcak, 2008). In summary then, our study suggests that emotion regulation via appraisal frames may be an efficient way to alter both the emotional experience and the facial expressions accompanying negative affect. Thus, people experiencing difficulties in regulating negative affect may benefit from generating proper interpretations in advance.

Second, we investigated the effects of appraisal frames on pleasant stimuli, which is a critical extension of recent publications on cognitive regulation of positive emotions (Giuliani et al., 2008; Krompinger et al., 2008; Delgado et al., 2008). Our results demonstrate that positive narratives preceding pleasant pictures (i.e., pleasant-positive condition) enhanced pleasantness compared to neutral narratives (i.e., pleasant-neutral condition) as reflected in self-reported valence and increased activity of the zygomaticus major muscle. Combining these results with the observed impact of appraisal frames on unpleasant stimuli, we conclude that the effect of appraisal frames may not be specific to negative valence. Therefore, appraisal frames could be applied not only to modulate negative emotions but also to alter positive emotions.

However, self-reported arousal was not affected by appraisal frames preceding pleasant pictures. This finding may suggest valence-specific effects of appraisal frames on emotional arousal. However, this result may also be related to actual arousal differences between the pleasant compared to the unpleasant pictures. Thus, future studies may address this issue by examining the cognitive and neural mechanisms underlying the regulation of positive and negative emotions depending on their arousal level.

Third, the analysis of the temporal dynamic of EMG responses revealed that the effect of appraisal frames on facial expression becomes evident between 0.5 and 1 s after stimulus onset for both the corrugator supercilii and the zygomaticus major muscles. These effects of appraisal frames on EMG activity are probably much faster than the emergence of conscious emotional experience evoked by emotional stimuli (e.g., within 4 s from picture onset according to Dan Glauser and Scherer, 2008) as well as heart rate and skin conductance responses (within 5 s from picture onset, see Dan Glauser and Scherer, 2008; Dimberg et al., 1998). The rapid response in facial expression to emotion regulation may imply an important role of facial feedback in the modifications of emotional experience (Buck, 1980). It will be interesting for future studies to investigate how facial expressions interact with emotional experience as well as other emotional response systems, e.g., heart rate, skin conductance, and neural activity (Gerdes et al., 2010; Muhlberger et al., 2010).

Finally, this study replicates and further extends prior work indicating that unpleasant stimuli evoke mainly activity over the corrugator supercilii muscle while pleasant stimuli evoke mainly zygomaticus muscle activity (Cacioppo et al., 1986; Lang et al., 1993). Our results suggest that regulation of negative or positive emotions may affect mainly corrugator supercilii or zygomaticus major activity, respectively. We conclude that both measures may have to be used to adequately determine the outcome of emotion regulation on positive and negative affective states. Additionally, considering the importance of facial muscle movement in social communication, our results implicate that appraisal frames can help generating proper social behaviors, i.e., reducing negative facial muscle movements and enhancing positive facial expressions during social interaction, and thus improving social adaptation in both clinical and healthy populations.

There are also some limitations of the present study. Firstly, it should be noted that although we carefully refrained from mentioning ‘emotion regulation’ or ‘facial expression’ in our instructions, participants may have still inferred the purpose of the study. Thus, they may have responded in a way that conforms to the hypotheses of this study. However, such demand effects are a general problem in studies on emotion regulation. Future studies that combine EMG with “less controllable” measures such as EEG and/or fMRI may offer further evidence. Secondly, our sample size ($N = 20$) is relatively small, although comparable with several previous studies (de Morree and Marcora, 2011; Korb et al., 2010; Cannon et al., 2009). Therefore, replication studies with larger sample sizes are needed, especially to confirm our tentative conclusion that regulation of negative and positive emotions are differentially reflected in corrugator and zygomaticus activity, respectively. Lastly, to keep the task brief (i.e., within 1 h), we didn't include emotional contradictory conditions (i.e., an unpleasant-positive condition and a pleasant-negative condition). Therefore, it remains to be clarified by future studies how neutral narratives differ from contradictory narratives in reducing responses to emotional stimuli.

In conclusion, our study provides support to the assumption that preceding appraisal frames can alter both emotional experience and facial expression. It extends previous work by revealing the efficacy of appraisal frames in modulating multiple systems of positive as well as negative emotional responses. In addition, this study shows that appraisal frames rapidly (within 1 s after picture onset) affect valence-specific activity patterns of corrugator supercilii and zygomaticus major muscles, both of which are important signs of emotions in social interaction.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ijpsycho.2012.04.010.

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