Facial expression arousal level modulates facial mimicry

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ABSTRACT

We investigated the effect of facial expression arousal level and mode of presentation on facial mimicry. High- and low-arousal facial expressions indicating pleasant and unpleasant emotions were presented both statically and dynamically. Participants' facial electromyographic (EMG) reactions were recorded from the zygomatic major and corrugator supercilii muscles. Stronger zygomatic major muscle activity was evoked for high- compared to low-arousal pleasant expressions. Comparable activity was induced in the corrugator supercilii muscle in response to both high- and low-arousal unpleasant expressions, and this was true for both dynamic and static presentation. These results suggest that the arousal levels of pleasant, but not unpleasant, facial expressions can enhance facial mimicry.

Keywords:

Arousal

Electromyography (EMG)

Facial mimicry

Dynamic facial expressions

1. Introduction

People often produce facial movements congruent with others when looking at emotional facial expressions. This phenomenon is known as facial mimicry and plays an important role in nonverbal communication (Dimberg, 1982). Facial mimicry has been studied in the context of a wide variety of fields, including social factors (McHugo et al., 1991; Vrana and Gross, 2004), psychotherapy (Rogers, 1957), and emotional contagion (Hatfiel et al., 1993). Facial muscle activity evoked in observers is usually recorded using facial electromyography (EMG), which can detect subtle facial movements that are not discernible to the naked eye. Previous studies have demonstrated that photographic presentation of happy facial expressions induces zygomatic major muscle activity (pulling of lip corners, prototypical in happy facial expressions) in observers, whereas angry facial expressions evoke corrugator supercilii muscle activity (lowering of the brows, prototypical in angry facial expressions) (Dimberg, 1982, 1997).

The majority of previous studies focusing on facial mimicry have employed happy and angry facial stimuli as pleasant and unpleasant expressions. These studies are based on the discrete emotion theory (Ekman, 1972) that suggests six basic facial expressions exist. The various theories regarding emotional facial expressions remain disputed (e.g., Scherer et al., 2007; for a review, see Russell et al., 2003). One theory proposes that facial expressions are interpreted based on two dimensions, their emotional valence (i.e., indicating pleasure or unpleasure) and degree of arousal

(Russell and Bullock, 1985). Accordingly, the dimensions of valence and arousal might be important factors for understanding facial mimicry. Happy and angry facial expressions represent high arousal levels in the dimensional view (Russell and Bullock, 1985), and it has been shown that happy and angry expression stimuli used in several previous studies on facial EMG activity (Ekman and Friesen, 1976) were indeed rated as high-arousal (Vrana and Gross, 2004). Therefore, the results of these studies only address facial mimicry with respect to high-arousal emotional expressions. A study has suggested that that arousal corresponds to the intensity of emotion (Lang et al., 1998). Given that the high-arousal leads to strong emotional intensity of facial expressions, greater facial EMG activity would be expected to be induced in response to high-arousal than low-arousal facial expressions.

Previous studies found comparable facial EMG activity in response to sad and angry facial expressions (Lundqvist and Dimberg, 1995; Sonnby-Borgström et al., 2008). Sad facial expressions are normally thought to indicate low arousal levels (Russell and Bullock, 1985), and hence these data suggest that high- and low-arousal unpleasant expressions have similar potential for facial mimicry. However, these experiments did not quantify the arousal level of their stimuli, and thus the possibility exists that some sad face stimuli could indicate high-arousal/intensity levels (e.g., Anttonen et al., 2009; Harrison et al., 2007). As such, whether high- and low-arousal unpleasant facial stimuli induce comparable facial EMG activity remains unclear.

Furthermore, whether facial EMG activity in response to pleasant facial expressions differs between high and low-arousal levels is unknown. Consequently, no extant studies have systematically examined the relationship between arousal level and facial mimicry by employing high- and low-arousal pleasant and unpleasant facial expressions as stimuli.

Many studies have suggested that the arousal level of emotional events can modulate facial EMG reactions. For example, Greenwald et al. (1989) recorded facial EMG activity in response to emotional scenes that varied widely across the dimensions of valence and arousal. They reported a trend toward a positive association between arousal ratings and zygomatic major (but not corrugator supercilii) muscle activity. Witvliet and Vrana (1995) assessed facial EMG activity while subjects imagined emotional events with high- and low-arousal levels as well as pleasant and unpleasant meanings. They found that zygomatic major muscle activity was higher during pleasant, high-arousal conditions than pleasant, low-arousal conditions, whereas corrugator supercilii activity was not. Based on these data, we hypothesized that zygomatic major muscle activity is greater for high-arousal than low-arousal pleasant facial expression stimuli.

In addition to the static facial expression stimuli used in several previous studies, we also tested dynamic facial expression stimuli. As dynamic facial expressions represent the natural form of communication in daily life, the use of these stimuli increases the ecological validity of our results. Consistent with this notion, recent studies have shown that compared to static expressions, presentation of dynamic facial expressions enhanced facial EMG reactions without any qualitative changes (Sato et al., 2008; Weyers et al., 2006). Based on these data, we hypothesized that the aforementioned effect of arousal on facial mimicry would be evident and qualitatively comparable for dynamic and static facial expressions.

To test these hypotheses, we presented high- and low-arousal facial expressions indicating pleasant and unpleasant emotions in both static and dynamic presentation. For dynamic stimuli, the sequence from a neutral to full-blown expression was presented. For static stimuli, a full-blown expression was presented as a still. EMG activity was recorded from the zygomatic major and corrugator supercilii muscles.

2. Method

2.1. Participants

Thirty-eight Japanese volunteers (33 women and 5 men; mean ± SD age, 20.65 ± 0.8 years) participated in this experiment. Subjects were recruited from undergraduate psychology classes and given extra credit for their participation. All participants had normal or corrected-to-normal visual acuity. Written informed consent was obtained from all participants after the experimental procedure had been explained.

2.2. Facial stimuli

Facial expression stimuli were presented in the form of video footage (30 frames/s) of four Japanese amateur models used in a previous study (Fujimura and Suzuki, 2007). The models were asked to express natural facial expressions while imagining a variety of emotional events (e.g., pleasant-high arousal, “you win the lottery unexpectedly”; pleasant-low arousal, “you are lying in the sun”; unpleasant-high arousal, “your friend broke a promise”; unpleasant-low arousal, “you are crossed in love”). We recorded expressions made by both men and women, but only the women expressed emotions clearly. This observation was consistent with findings indicating that women express emotions via the face more accurately and intensely than men (Hall, 1984). The stimuli used are located in each quadrant on the emotional space constructed of valence and arousal (see as Fig. 1), and include pleasant-high arousal, pleasant-low arousal, unpleasant-high arousal, and unpleasant-low arousal.

[Figure 1]

For dynamic stimuli, the sequence from a neutral to a full-blown expression was presented. For static stimuli, a full-blown expression was presented as a still, with a similar presentation duration as the corresponding dynamic stimuli. The mean presentation duration of each expression was as follows: pleasant-high arousal, 866 ms; pleasant-low arousal, 817 ms; unpleasant-high arousal, 825 ms; and unpleasant-low arousal, 1172 ms. All stimuli were presented in color.

To ensure the validity of the stimuli, we performed a preliminary study using the dynamic stimuli with 60 subjects who did not participate in the experiment (Fujimura and Suzuki, 2007). Subjects were instructed to evaluate each stimulus in regard to valence and arousal using a 9-point scale. The results confirmed that all stimuli displayed the target valence and arousal (e.g., high-arousal expressions were rated as having greater arousal than low-arousal expressions). In addition, a coder trained in the use of the Facial Action Coding System (FACS; Ekman and Friesen, 1978) evaluated the facial movements of the stimuli. The results confirmed that all pleasant expressions, both low and high arousal, showed Action Unit (AU) 12 (i.e., lip corner pulling), which is the prototypical facial muscle action in pleasant expressions. Moreover, all unpleasant expressions, regardless of arousal, showed AU 4 (i.e., brow lowering), the prototypical facial action in unpleasant expressions. In sum, these data support the validity of the present stimuli.

2.3. Apparatus

Experimental events were controlled by a program written in Visual C++5.0 and were implemented on a computer (Inspiron 8000, Dell) with the Microsoft Windows operating system. Stimuli were presented on a 19-inch CRT monitor (HM903D, Iiyama; 480 × 640 pixels, 16-bit color, 75 Hz refresh rate) from a viewing distance of about 0.6 m. The stimuli subtended a visual angle of about 16.5° × 11°. For the purpose of artifact rejection, sessions were recorded unobtrusively using a digital video camera (DSR-PD150, Sony).

2.4. Procedure

Experiments were conducted individually in an electrically shielded room. Upon arrival, participants were told that the EMG electrodes were harmless and that their task would be to evaluate the emotion portrayed by a facial stimulus. All the participants agreed to participate in the experiment. The EMG electrodes were placed on the left side of the face based on Dimberg and Petterson (2000), suggesting that the right brain hemisphere was responsible for the spontaneous emotional facial reactions.

After the electrode placement, the participants were asked to fill out questionnaires assessing empathy, which were aimed at enhancing their general adaptation to the experimental settings; they were given 15 min. After completing the questionnaires, the participants were told that they would be first viewing and then evaluating facial stimuli.

EMG recordings were conducted while the participants passively viewed the stimuli. The sequence of stimuli presentation incorporated the four types of emotions (i.e., combinations of pleasantness–unpleasantness and high arousal–low arousal). Each was presented dynamically and statically. In total, 32 trials were conducted, with the order of stimulus presentation randomized.

In each trial, a fixation point (a picture with a small gray "+" sign on a white background, the same size as the stimulus) was shown at the center of the screen for 1520 ms followed by presentation of the facial expression stimuli. The duration of presentation depended on the emotion portrayed. After stimulus presentation, the screen turned gray during the inter-trial interval, which varied randomly from 8000 ms to 10000 ms. During data acquisition, participants' motion was monitored with an oscilloscope and a video monitor, and stimulus presentation was suspended when participants were moving to prevent any motion artifact in the EMG signal.

To ensure that the facial stimuli conveyed the intended emotions, we conducted a rating session after EMG recording. Participants rated the emotional state of facial stimuli using the Affect Grid (Russell et al., 1989). The Affect Grid is a means of assessing affect along two dimensions: valence and arousal. Emotions were rated on a 9-point scale ranging from 1 (unpleasantness) to 9 (pleasantness) for valence and from 1 (sleepiness) to 9 (arousal) for arousal. Finally, the participants were interviewed to confirm that they were unaware of the purpose of the experiment.

2.5. EMG recording

EMG recordings for the corrugator supercilii and zygomatic major muscles were conducted using Ag/AgCl electrodes (NT-611U, Nihonkoden). The electrodes were placed as per the guidelines of Fridlund and Cacioppo (1986). Impedances were balanced and maintained below 15 kΩ. The data were amplified and filtered online (band pass: 50–500 Hz; notch: 60 Hz) by a polygraph (NEC, Synafit 1000) and sampled by a digital converter system (MP100, BIOPAC Systems) at 1000 Hz.

2.6. Data analysis

EMG data were analyzed using Psychophysiological Analysis Software 3.3 (Computational Neuroscience Laboratory of the Salk Institute) implemented in MATLAB 6.5 (Mathworks). Data were sampled for 3500 ms in each trial, which consisted of pre-stimulus baseline data for 1000 ms (i.e., during presentation of the fixation point) and the poststimulus onset data for 2500 ms. The time window of the poststimulus period was identical to a previous EMG study that detected facial muscle reactions in response to dynamic facial expressions (Sato et al., 2008).

Because the data included various types of motion artifacts (e.g., mumbling), session videotapes and raw EMG data were examined as per published guidelines (e.g., Gerleman, 1992). Artifact-contaminated trials were rejected from subsequent analyses. To ensure data were collected from at least two repetitions for each condition, we also excluded participants who had more than three trials for a condition rejected from further analysis, leaving at total of 32 participants. The frequency of artifact-contaminated trials was as follows (mean ± *SD*): dynamic pleasant-high arousal, 0.28 ± 0.56; dynamic pleasant-low arousal, 0.19 ± 0.61; dynamic unpleasant-high arousal, 0.38 ± 0.58; dynamic unpleasant-low arousal, 0.31 ± 0.64; static pleasant-high arousal, 0.38 ± 0.64; static pleasant-low arousal, 0.41 ± 0.66; static unpleasant-high arousal, 0.38 ± 0.72; and static unpleasant-low arousal, 0.31 ± 0.50. For each trial, the differences in the mean absolute EMG amplitudes between the pre-stimulus and poststimulus periods were calculated. For statistical analysis using ANOVA, EMG data were transformed into within-subjects *z*-scores for each muscle site based on previously published studies (e.g., Hess and Blairy, 2001). EMG data were averaged for each condition for each participant and then analyzed by three-way repeated-measures ANOVA with presentation condition, valence, and arousal level as the factors.

3. Results

3.1. Mean rating of experienced emotions

Table 1 shows subjective emotional states when the participants were viewing each facial stimulus. To confirm that the emotion elicited by these facial stimuli was differentiated with respect to valence and arousal, one-tailed *t*-tests were conducted for each pair of stimuli. Pleasant expressions were rated as significantly more pleasant than unpleasant expressions under both dynamic and static conditions (high-arousal expressions: $ts(31) > 15.07$, $ps < .01$; low-arousal expressions: $ts(31) > 9.88$, $ps < .01$). High-arousal expressions were rated as significantly more aroused than low-arousal expressions under both presentation conditions (pleasant expressions: $ts(31) > 3.51$, *p*s< .01; unpleasant expressions: *t*s(31) > 8.54, *p*s < .01). The results demonstrate that the facial stimuli expressed the intended emotions to the participants.

[Table 1]

3.2. Zygomatic major

Zygomatic major muscle activity for each expression is shown in Fig. 2(a). The three-way ANOVA showed a significant main effect of valence ($F(1, 31) = 5.73$, $p < .05$, $\eta_p^2 = 0.16$), indicating a significantly different pattern of zygomatic major activity for pleasant and unpleasant expressions. Significant interactions were observed between valence and arousal level ($F(1, 31) = 4.32$, $p < .05$, $\eta_p^2 = 0.12$) and valence and condition ($F(1, 31) = 4.42$, $p < .05$, $\eta_p^2 = 0.013$). Other main effects and interactions were not significant (*F*s(1, 31) < 2.60, *n.s.*).

[Figure 2]

Follow-up ANOVAs revealed that high-arousal pleasant expressions induced significantly stronger zygomatic major activity than low-arousal pleasant expressions ($F(1, 62) = 3.15$, $p < .05$), and that pleasant expressions evoked greater zygomatic major activity than unpleasant expressions under the high-arousal condition ($F(1, 62) = 13.13$, $p < .01$), but not the low-arousal condition ($F(1, 62) = 0.19$, *n.s.*). With respect to presentation condition, pleasant expressions produced significantly greater zygomatic major activity compared to unpleasant expressions under the dynamic condition (*F*(1,

62) = 9.46, $p < .01$), but not the static condition ($F(1, 62) = 1.48$, *n.s.*)

3.3. Corrugator supercilii

Fig. 2(b) shows corrugator supercilii muscle activity for each expression. The ANOVA yielded the significant main effects of valence ($F(1, 31) = 6.69$, $p < .05$, $\eta_p^2 = 0.18$). The interaction between presentation condition and valence was also significant ($F(1, 31) = 6.35$, $p < .05$, $\eta_p^2 = 0.17$). Follow-up ANOVAs showed that unpleasant expressions induced significantly greater corrugator muscle activity than pleasant expressions under the dynamic condition ($F(1, 62) = 11.10$, $p < .01$), but not the static condition ($F(1, 62) = 2.18$, *n.s.*). Other main effects and interactions did not reach significance ($Fs(1, 31) < 2.09$, *n.s.*)

4. Discussion

Our results demonstrated that pleasant expressions induce stronger zygomatic major EMG activity than unpleasant expressions, and conversely, that unpleasant expressions induce stronger corrugator supercilii EMG activity than pleasant expressions. These overall patterns are consistent with the results of previous studies on facial mimicry (e.g., Dimberg, 1982).

More importantly, our results showed that the zygomatic major muscle activity is stronger for high- versus low-arousal pleasant expressions. This result is in line with previous studies reporting that the arousal level of emotional stimuli/events influenced zygomatic activity (Greenwald et al., 1989; Witvliet and Vrana, 1995). Furthermore, Lang et al. (1998) suggested that the arousal dimension on the emotional space can be interpreted as emotional intensity. Thus, the higher the arousal level of a pleasant facial expression is, the greater the pleasant intensity of the underlying emotion will be. Moreover, a recent facial EMG study reported that rapid facial reactions to faces do not reflect purely motor processes, but rather are also influenced by emotion (Moody et al., 2007). These data suggest that increased intensity of pleasant facial expressions may lead to greater zygomatic major activity in observers.

In contrast, corrugator supercilii muscle activity showed no significant differences between high- and low-arousal unpleasant expressions. This finding suggests that facial mimicry in response to unpleasant expressions is not influenced by the arousal level of the expression. Because the stimuli used for high- and low-arousal unpleasant expressions could be described as “angry” and “sad” according to categorical choices (Fujimura and Suzuki, 2007), our results are consistent with previous studies reporting comparable EMG activity in response to angry and sad expressions (Lundqvist and Dimberg, 1995; Sonnby-Borgström et al., 2008). These data suggest that low-arousal of emotion notwithstanding, sad facial expressions have potential for facial mimicry comparable with angry expressions. Bavelas et al. (1986) stated that displaying expressions congruent with others’ sad expressions indicated empathy and support toward others. Accordingly, facial mimicry in response to sad expressions may have a social function with respect to emotional communication with others. Conversely, congruent facial reactions to angry faces facilitate the detection of anger by the interaction partner (Weyers et al., 2006), rather than promoting empathy. Thus, facial mimicry for sad and angry faces has different functions and represents independent emotional categories. Accordingly, facial mimicry in response to unpleasant expressions may be better accounted for by the discrete emotion theory rather than dimensional theory.

The effect of arousal level on facial mimicry in response to pleasant expressions was similar for dynamic and static facial expressions. This finding is valid, as the use of dynamic facial expressions increases ecological validity. We found no differences between dynamic and static stimulus presentation, which is in contrast to previous studies (Sato et al., 2008; Weyers et al., 2006). However, both zygomatic major activity and corrugator activity in response to the corresponding emotional facial stimuli (pleasant or unpleasant stimuli, respectively) was greater than in response to the opposite facial stimuli, and this effect was more robust with dynamic stimulus presentation compared to static presentation. This suggests that dynamic presentation may increase the sensitivity of the facial muscle response to the valence of observed facial expressions; i.e., zygomatic major activity is more sensitive to pleasant expressions and less sensitive to unpleasant expressions.

Some limitations of the present study should be acknowledged. First, the arousal and valence of expression stimuli were confounded by the duration of the expression shown to subjects. However, this issue is unavoidable due to dynamic facial expressions naturally changing. A previous study reported that sad expressions were rated as more natural than angry expressions when presented at a lower speed, and that the velocity was related to the arousal level of facial expressions (Sato and Yoshikawa, 2004). Hence, producing natural expression stimuli of different emotions that occur at the same speed is difficult. Future studies that systematically control the speed of facial expression change may help clarify this issue.

Second, the gender of both our participants and stimulus models was unequally distributed. The majority of participants and all stimulus models were female. However, a previous study reported that facial mimicry was not qualitatively different between female and male subjects (Dimberg and Lundqvist, 1990), suggesting that the gender bias in the participants would not severely influence our results. With respect to stimulus models, Vrana and Gross (2004) reported that expressions produced by males induced greater zygomaticus EMG activity than in females. As such, our findings regarding zygomatic activity to pleasant expressions might be clearer with male models.

Finally, we did not explore facial EMG activity in response to neutral facial expressions. Creating dynamic face stimuli without some form of emotional meaning comparable with dynamic emotional expressions is difficult (cf. Sato et al., 2004).

Given that facial mimicry comprises not simply facial reactions but is also influenced by context such as the gender or ethnicity of facial stimuli (Vrana and Gross, 2004), facial activities in response to neutral stimuli should be examined in future studies.

In summary, our results demonstrate that stronger facial mimicry occurs in response to high- compared to low-arousal pleasant expressions. These findings suggest that the arousal level of pleasant facial expressions can affect facial mimicry, and that facial mimicry in response to pleasant and unpleasant expressions may rely on different mechanisms.

References

Anttonen, J., Surakka, V., & Koivuluoma, M. (2009). Ballistocardiographic responses to dynamic facial displays of emotion while sitting on the EMFi chair. J. Media Psychol. 21, 69-84.

Bavelas, J. B., Black, A., Lemay, C. R., Mullet, J. 1986. Experimental methods for studying “elementary motor mimicry”. J. Nonverbal Behav. 10, 102-119.

Dimberg, U. 1982. Facial reactions to facial expressions. Psychophysiology 19, 643-647.

Dimberg, U. 1997. Facial reactions: Rapidly evoked emotional responses. Journal of Psychophysiology 11, 115-123.

Dimberg, U., Lundqvist, L.O. 1990. Gender differences in facial reactions to facial expressions. Biol. Psychol. 30, 151-9.

Dimberg U, Petterson M. 2000. Facial reactions to happy and angry facial expressions: evidence for right hemisphere dominance. Psychophysiology 37, 693-6.

Ekman, P. 1972. Universal and cultural differences in facial expressions of emotion, In J. K. Cole (Ed.), Nebraska symposium on motivation: Vol. 19. Lincoln, NE: University of Nebraska Press, pp.207-283.

Ekman, P., Friesen, W. V. 1976. Pictures of facial affect. Palo Alto, CA: Consulting Psychologist.

Ekman, P., Friesen, W. V. 1978. Facial Action Coding System. Consluting Psychologist, Palo Alto.

Fujimura, T., Suzuki, N. 2007. Effects of temporal information and configuration change on the recognition of emotional facial expressions: based on dimensional perspective. J. Jpn. Cogn. Psychol. 5, 53-61.

Fridlund, A. J., Cacioppo, J. T. 1986. Guidelines for human electromyographic research. Psychophysiology 23, 567-589.

Gerleman, D. G. 1992. Instrumentation. In: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, (ed.), Selected Topics in Surface Electromyography for Use in the Occupational Setting: Expert Perspectives, National Institute for Occupational Safety and Health, Atlanta, pp. 43-68.

Greenwald, M.K., Cook, E. W. Lang, P. J. 1989. Affective judgement and psychophysiological response: dimensional covariation in the evaluation of pictorial stimuli. J. Pyschophysiol. 3, 51-64.

Hall, J. A. 1984. Nonverbal sex differences. Baltimore: johns Hopkins Universtity press.

Harrison, N. A., Wilson, C. E., & Critchley, H. D. 2007. Processing of observed pupil size modulates perception of sadness and predicts empathy. Emotion 7, 724-729.

Hatfield, E., Cacioppo, J. T., Rapson, R. L. 1993. Emotional contagion. Curr. Dir. Psychol. Sci. 2, 96-99.

Hess, U., Blairy, S. 2001. Facial mimicry and emotional contagion to dynamic emotional facial expressions and their influence on decoding accuracy. Int. J. Psychophysiol. 40, 129-141.

Lang, P. J., Bradley, M. M., Cuthbert, B. N. 1998. Emotion, motivation, and anxiety: Brain mechanisms and psychophysiology. Biol. Psychiatry. 44, 1248-1263.

Lundqvist, L. O., Dimberg, U. 1995. Facial expressions are contagious. Journal of Psychophysiology 9, 203-211.

McHugo, G. J., Lazetta, J. T., Bush, L.K. 1991. The effects of attitudes on emotional reactions to expressive displays of political leaders. J. Nonverbal Behav. 15, 19-41.

Moody, E. J., McIntosh, D. N., Mann, L. J., Weisser, K. R. 2007. More than mimicry?

The influence of emotion on rapid facial reactions to faces. Emotion. 7, 447-457.

Rogers, C. R. 1957. The necessary and sufficient conditions of therapeutic personality change. J. Consult. Psychol. 21, 95-103.

Russell, J.A, Bachorowski, J.A, Fernandez-Dols, J.M. (2003). Facial and vocal expressions of emotion. Annu Rev Psychol. 54, 329-49.

Russell, J. A., Bullock, M. 1985. Multidimensional scaling of emotional facial expressions: Similarity from preschoolers to adults. J. Pers. Soc. Psychol. 48, 1290-1298.

Russell, J. A., Weiss, A., Mendelsohn, G. A. 1989. Affect Grid: A single-item scale of pleasure and arousal. J. Pers. Soc. Psychol.57, 493-502.

Sato, W., Fujimura, T., Suzuki, N. 2008. Enhanced facial EMG activity in response to dynamic facial expressions. Int. J. Psychophysiol. 70, 70-74.

Sato, W., Kochiyama, T., Yoshikawa, S., Naitoa, E., Matsumura, M. 2004. Enhanced neural activity in response to dynamic facial expressions of emotion: an fMRI study. Cogn. Brain Res. 20, 81-91.

Sato, W., Yoshikawa, S. 2004. The dynamic aspects of emotional facial expressions. Cogn. Emot. 18, 701-710.

Scherer, K. R., Ellgring, H. 2007. Are facial expressions of emotion produced by categorical affect programs or dynamically driven by appraisal? Emotion. 7, 113-130.

Sonnby-Borgström, M., Jönsson, P., Svensson, O. 2008. Gender differences in facial imitation and verbally reported emotional contagion from spontaneous to emotionally regulated processing levels. Scand. J. Psychol. 49, 111-22.

Vrana, S. R., Gross, D. 2004. Reactions to facial expressions: effects of social context and speech anxiety on responses to neutral, anger, and joy expressions. Biol. Psychol. 66, 63-78.

Weyers, P., Muhlberger, A., Hefele, C., Pauli, P. 2006. Electromyographic responses to static and dynamic avatar emotional facial expressions. Psychophysiology 43, 450-453.

Witvliet C. V., Vrana, S. R. 1995. Psychophysiological responses as indices of affective dimensions. Psychophysiology. 32, 436-443.

Table 1 Mean (with SE) rating of experienced emotion (*N* =32)

Ratings	Presentation Mode	Facial Stimuli							
		Pleasantness				Unpleasantness			
		High-Arousal		Low-Arousal		High-Arousal		Low-Arousal	
Valence	Dynamic	7.59	(0.18)	6.57	(0.21)	2.49	(0.18)	3.23	(0.15)
	Static	7.55	(0.18)	6.66	(0.20)	2.41	(0.19)	3.42	(0.17)
Arousal	Dynamic	6.94	(0.17)	4.23	(0.21)	6.57	(0.19)	4.23	(0.15)
	Static	6.91	(0.18)	4.62	(0.18)	6.63	(0.17)	4.26	(0.21)

Note. Scores ranged from 1 (unpleasantness or low arousal) to 9 (pleasant or high arousal).

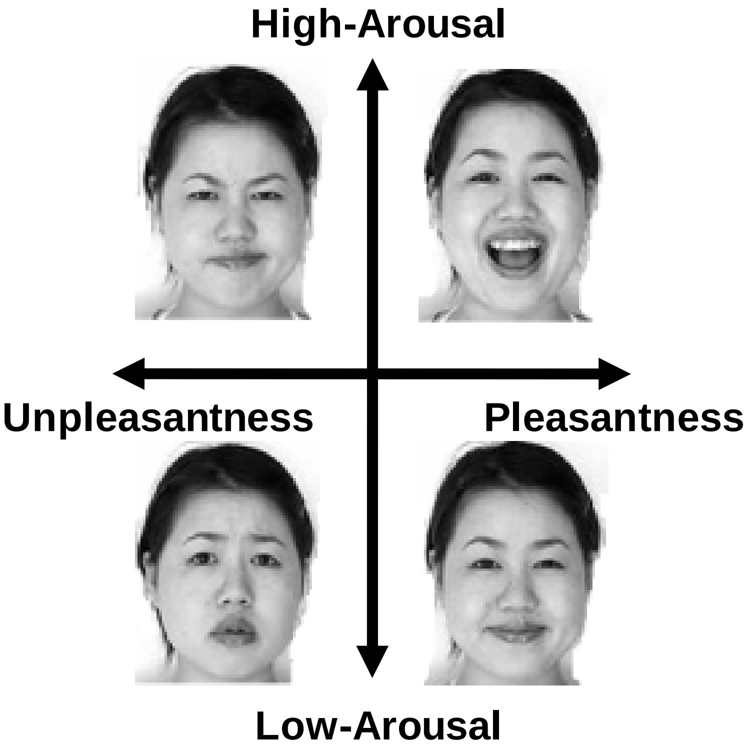

Figure 1. Facial stimuli located in each quadrant on an emotional space constructed of valence and arousal.

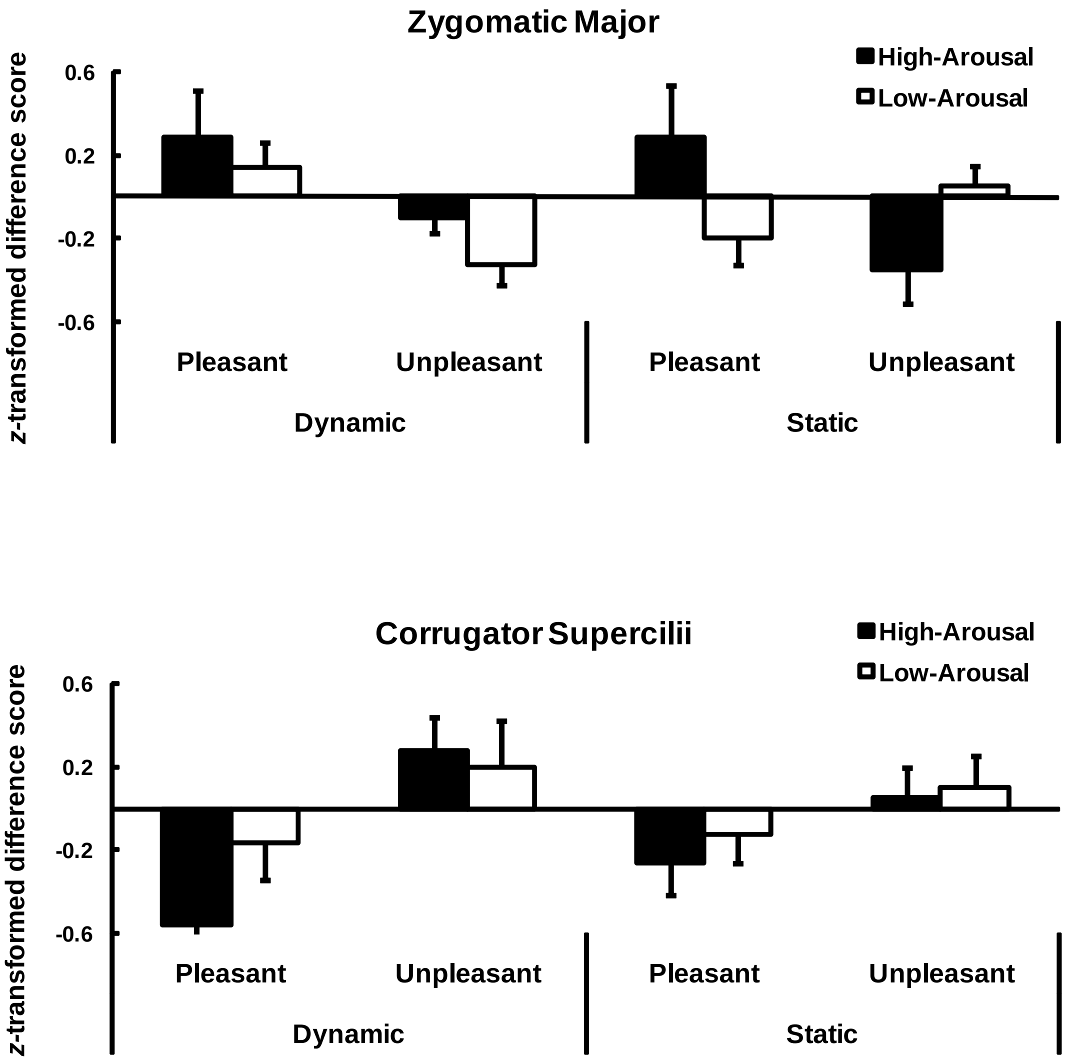

Figure 2. Means EMG change activity and standard errors for (a) zygomatic major muscle and (b) corrugators supercilii