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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 presentations. These results suggest that the arousal levels of pleasant, but not unpleasant, facial expressions can enhance facial mimicry.

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 (Hatfield 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 and Ellgring, 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 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

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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.

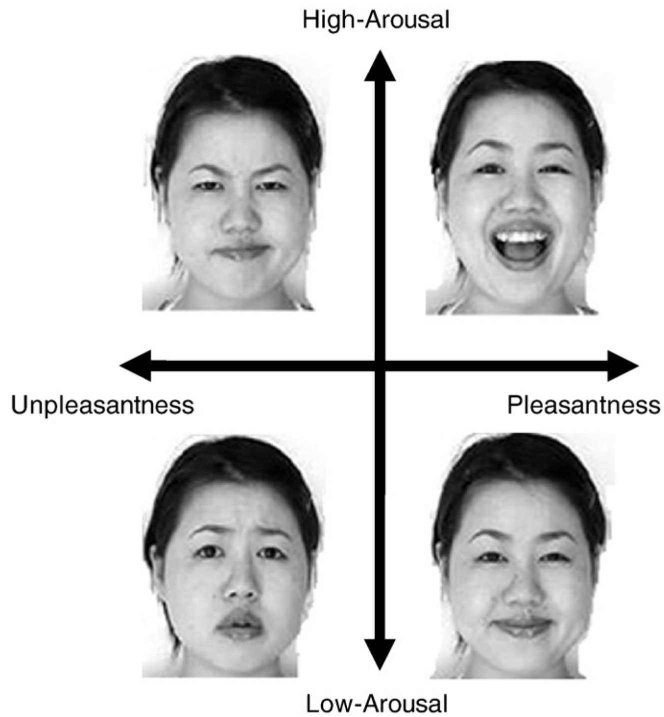

Fig. 1. Facial stimuli located in each quadrant on an emotional space constructed of valence and arousal.

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 Fig. 1), and include pleasant-high arousal, pleasant-low arousal, unpleasant-high arousal, and unpleasant-low arousal.

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).