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Enhanced facial EMG activity in response to dynamic facial expressions

Wataru Sato [a,*,1], Tomomi Fujimura [b,c], Naoto Suzuki [b]

[a] Department of Comparative Study of Cognitive Development, Primate Research Institute, Kyoto University, Aichi 484-8506, Japan
[b] Department of Psychology, Graduate School of Letters, Dosisha University, Imadegawa, Kamigyo-ku, Kyoto 602-8580, Japan
[c] Japan Society for the Promotion of Science, Ichiban-cho, Chiyoda-ku, Tokyo 102-8472, Japan

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ABSTRACT

The suggestion that dynamic facial expressions of emotion induce more evident facial mimicry than static ones remains controversial. We investigated this issue by recording EMG from the corrugator supercilii and zygomatic major. Dynamic and static facial expressions of anger and happiness were presented. Dynamic presentations of angry expressions induced stronger EMG activity from the corrugator supercilii than static presentations, while dynamic presentations of happy expressions induced stronger EMG activity from the zygomatic major compared to static presentations. These results indicate that dynamic facial expressions induce facial EMG activity interpretable as facial mimicry more evidently than static expressions.

1. Introduction

Communication through facial expressions of emotion plays an important role in social coordination (Keltner and Kring, 1998). Throughout the evolutionary process, facial expressions have helped humans act collectively during times of danger and form close relationships with one another. Consistent with this idea, psychophysiological studies using facial electromyography (EMG) indicate that facial expressions elicit facial muscular activity congruent with the presented facial expressions. For example, Dimberg (1982) showed that mere photographic presentations of angry and happy facial expressions induced corrugator supercilii muscle activity (brow lowering actions, prototypical in angry facial expressions) and zygomatic major muscle activity (lip corner pulling actions, prototypical in happy facial expressions), respectively. This facial muscular activity can be interpreted as mimicking behavior or facial mimicry (Hess et al., 1999). Dimberg and Thunberg (1998) showed that facial EMG activity occurred rapidly after about 500 ms from the onset of facial pictures. Dimberg et al. (2000) reported that facial EMG activity occurred even without awareness of the specific facial expression. These data indicate that facial EMG activity interpretable as facial mimicry occurs rapidly and automatically in response to stimulus facial expressions.

Dynamic facial expressions of emotion are ecologically valid and powerful media for emotional communication compared to static expressions. Several lines of psychological studies have investigated the effect of dynamic presentations of facial stimuli and reported a facilitative effect on facial processing. For example, the dynamic presentation of facial expressions has been shown to improve the emotional recognition of expressions (Frijda, 1953; Harwood et al., 1999; Wehrle et al., 2000). Other research has found that the dynamic presentation of facial stimuli facilitated age (Berry, 1990) and identity recognition (Bruce and Valentine, 1988; Lander et al., 1999) compared to static image presentations. Therefore, it appears reasonable to expect dynamic facial expressions to elicit facial mimicry more evidently than static ones.

However, only a few studies have investigated this issue, and data are inconsistent. Weyers et al. (2006) presented dynamic and static facial expressions of anger and happiness using avatars, that is, computer-generated artificial faces. They took EMG recordings from the facial muscles of the corrugator supercilii and zygomatic major. Their results showed that dynamic presentations of happy expressions induced stronger EMG reactions for zygomatic major muscles compared to static presentations. This result is consistent with the idea that dynamic facial expressions induce more evident facial mimicry than static expressions. However, for angry facial expressions, they found no significant differences between dynamic and static presentations for corrugator supercilii muscle activity.

Sato and Yoshikawa (2007a) investigated this issue utilizing a different methodology. They presented dynamic and static facial expressions of anger and happiness, using computer-morphing techniques and videos of real people. The participants' facial reactions were unobtrusively videotaped and blindly coded using an objective criterion (Ekman and Friesen, 1978). In the case of dynamic, but not

* Corresponding author. Tel.: +81 568 63 0567; fax: +81 568 63 0085.
E-mail address: sato@pri.kyoto-u.ac.jp (W. Sato).
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static, presentations, brow lowering and lip corner pulling were evident for angry and happy expressions, respectively. These results indicate enhanced facial mimicry for dynamic facial expressions, common to both anger and happiness.

The different results in these previous studies (Sato and Yoshikawa, 2007a; Weyers et al., 2006) may have been caused by differences in the stimuli that were presented. Whereas Weyers et al. (2006) utilized artificial avatars, Sato and Yoshikawa (2007a) applied representations of real peoples' faces. A recent neuroimaging study revealed that the activity of some social- and/or emotion-related brain regions, such as the amygdala, was lower when viewing avatars than when viewing real-person stimuli (Moser et al., 2007). The dynamic stimuli of real people may be more ecologically valid than dynamic avatars and hence, induce clearer facial mimicry. In this study, we utilized the stimuli of real people to test the hypothesis that enhanced facial EMG reactions could be induced by dynamic rather than static facial expressions of both negative and positive stimuli.

We measured facial EMG reactions while participants passively viewed dynamic and static facial expressions. To present dynamic facial expressions, we used videos of real people's facial expressions, which had been used in a previous behavioral study and were shown to elicit automatic facial mimicry more evidently than static facial images (Sato and Yoshikawa, 2007a). We prepared facial expressions of anger and happiness to represent the positive and negative emotional valence. We used the apex images of the dynamic facial expressions under static conditions. After the facial EMG recordings, we presented the stimuli again, and required the participants to rate the experienced emotion and recognized emotion of the stimuli. We predicted that specific facial EMG reactions, interpretable as facial mimicry, would occur more evidently for dynamic rather than for static facial expressions of emotion.

2. Method

2.1. Participants

Twenty-nine volunteers (18 females and 11 males; mean ± SD age, 20.9 ± 0.9 years) participated in this experiment. All of the participants had normal or corrected-to-normal visual acuity. Although an additional male volunteer actually participated, his data were not analyzed due to outlier properties (see Data analysis). Informed consent was obtained from all participants in written form after the experimental procedures had been explained.

2.2. Experimental design

The experiment was constructed as a within-participants two-factorial design, with presentation condition (dynamic/static) and expression (angry/happy) as the factors.

2.3. Stimuli

The stimuli were the same as those used in a previous study (Sato and Yoshikawa, 2007a). The materials were video clips of angry and happy facial expressions of four females and four males. These stimuli were selected from a video database of facial expressions of emotion composed from more than 50 Japanese models. None of the faces was familiar to any of the participants. Preliminary ratings from 14 participants who did not take part in this experiment confirmed that the stimuli clearly displayed the target emotions relative to other basic emotions. In addition, a trained coder of the Facial Action Coding System (FACS; Ekman and Friesen, 1978) evaluated the stimulus facial actions, and the FACS data were subjected to the Facial Action Coding System Affect Interpretation Dictionary (FACSAID; Ekman et al., 1998). The results confirmed that the emotional meanings of the stimulus facial actions could be recognized as intended. Specifically, all of the selected angry and happy expressions showed action units 4 (brow lowering) and 12 (lip corner pulling), respectively. The expressions contained few artifacts irrelevant to emotional expressions.

For the dynamic expression stimuli, 38 frames from neutral to emotional expressions were presented. Each frame was shown for 40 ms, and each clip was presented for 1520 ms.

The frames of the apex emotional expressions in the dynamic condition were prepared for the static expression stimuli and presented for 1520 ms.

2.4. Apparatus

Experimental events were controlled by a program written in Visual C++5.0 and implemented on a computer (Inspiron 8000, Dell) with a Microsoft Windows operating system. The stimuli were presented on a 19 in. CRT monitor (HM903D, Iiyama; 480 vertical × 640 horizontal pixels resolution, 16 bit color, 75 Hz refresh rate) from a viewing distance of about 0.6 m. The stimuli were presented at 300 pixels in height × 200 pixels in width, subtending a visual angle of about 16.5°in height × 11° in width.

2.5. Procedure

Experiments were conducted individually in an electrically shielded room. Upon arrival, participants were told that the experiment concerned sweat gland activity while evaluating some faces, which was the cover story to conceal our real purpose for making facial EMG recordings.

After electrode placement, the participants were asked to fill out dummy questionnaires for about 10 min, which were aimed at enhancing the participants' general adaptation to the experimental settings. After completing the questionnaires, the participants were told that they would be first viewing and then evaluating all of the stimuli.

The EMG recordings were conducted while the participants passively viewed the stimuli. In total, 32 trials were conducted, consisting of eight trials each of dynamic angry, dynamic happy, static angry, and static happy expressions. The order of stimulus presentation was randomized.

In each trial, a fixation point (the picture with a small "+" in a gray color on a white background and of the same size as the stimulus) was presented at the center of the screen for 1520 ms. Then, the stimulus was presented for 1520 ms. After stimulus presentation, the screen was filled with a gray color as an intertrial interval, which was controlled to vary randomly from 6000 ms to 9000 ms. Throughout the data acquisition, the participants' motion artifacts were monitored through an oscilloscope and a video monitor, and the stimulus presentations were suspended when the participants showed temporal movements.

After EMG recordings, the stimuli were again presented to the participants, and they evaluated each stimulus for the experienced emotion (i.e., the strength of the emotion that subjects felt when perceiving the stimulus models' expression) and the recognized emotion (i.e., the strength of the emotion that subjects recognized from the stimulus models' expression) using the affect grid (Russell et al., 1989), which graphically assessed the two dimensions of pleasure and arousal on 9-point scales. Russell et al. (1989) showed that the affect grid is suitable for assessing both recognized and experienced emotion. The two types of evaluation were presented in blocks, the order of which was counterbalanced across participants. The order of stimulus presentation was randomized in each block.

Finally, the participants were interviewed to determine whether they had been aware of the purpose of the experiment. This process confirmed that all of the participants had been unaware.

2.6. EMG recording

EMG recordings were taken for the corrugator supercilii and zygomatic major muscles using Ag/AgCl electrodes. The electrodes