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# ANTI-EXPRESSIONS: ARTIFICIAL CONTROL STIMULI FOR THE VISUAL PROPERTIES OF EMOTIONAL FACIAL EXPRESSIONS

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The perceptual/cognitive processing for emotional facial expressions is effective compared to that for neutral facial expressions. To investigate whether this effectiveness can be attributed to the expression of emotion or to the visual properties of the facial expressions, we used computer morphing to develop a form of control stimuli. These "anti-expressions" changed the features in emotional facial expressions in the opposite direction from neutral expressions by amounts equivalent to the differences between emotional and neutral expressions. To examine if anti-expressions are usable as emotionally neutral faces, 35 participants were asked to categorize and rate the valence and arousal dimensions of six basic emotions for normal and anti-expressions. The results indicate that anti-expressions were assessed as neutral for anger, disgust, fear, and happiness, and these can be used as control stimuli in emotional facial expressions regarding visual properties.

*Keywords:* anti-expressions, computer morphing, dimensional ratings, facial expressions, free responses.

Facial expressions of emotion are indispensable communicative media for human social life. Consequently, several psychological studies have investigated the processing of emotional facial expressions (e.g., Williams, Moss, Bradshaw,

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& Mattingley, 2005). Typically, in these studies, photographs of emotional expressions are presented to participants. Various types of perceptual/cognitive processes for emotional facial expressions are more effective than those for neutral facial expressions. For example, an emotional facial expression in a crowd of neutral facial expressions is more effectively detected than vice versa (e.g., Lamy, Amunts, & Bar-Haim, 2008; Williams et al., 2005). The identification of emotional facial expressions is more accurate than that of neutral facial expressions (e.g., Maxwell & Davidson, 2004; Milders & Sahraie, 2008; Milders, Sahraie, Logan, & Donnellon, 2006). The processing for faces is enhanced when faces have happy expressions compared to neutral expressions (e.g., Baudouin, Gilibert, Sansone, & Tiberghien, 2000; Gallegos & Tranel, 2005).

However, it remains unknown whether this effectiveness can be attributable to the expression of emotion or to the visual properties in the emotional facial expressions. Facial expressions of emotion have distinctive visual features compared to neutral expressions. For example, V-shaped eyebrows and U-shaped mouths are characteristic of angry and happy facial expressions, respectively, whereas neutral facial expressions contain relatively horizontal eyebrows and mouths (Lundqvist, Esteves, & Öhman, 1999). Psychophysical studies have shown that some visual features can be detected more quickly than others. For example, oblique lines and upturned curves are more rapidly detected than horizontal lines (Sagi & Julesz, 1986). It is intriguing to note that the typical changes of facial areas accompanying emotional expressions correspond to these features. If the changes of physical features in emotional facial expressions play an important role, then the results of previous studies could be interpreted without referring to the emotionality of the stimuli.

To investigate this issue, we propose a method of creating new control stimuli using a computer morphing technique. By manipulating two facial images with a computer, it is possible to create from the two a new facial image (Rowland & Perrett, 1995). Using this method, the photographs of an individual are used to show emotional and neutral facial expressions. After spatial standardization of the facial images, the metric differences in overall facial features between the emotional and neutral facial expressions are calculated and regarded to be 100%. The stimuli are then made by manipulating the metric differences into –100%, by changing the facial features for emotional facial expressions back in the opposite direction from the neutral expressions by an amount equivalent to the difference between the emotional and neutral expressions. For example, if the angry expression has V-shaped eyebrows and the neutral expression has horizontal eyebrows, the manipulation generates a face with Λ-shaped eyebrows. In line with the facial image-processing literature, in which the negative emphasizing of differences between the target and the norm stimuli is termed "anti-caricaturing" (Rhodes, Brennan, & Carey, 1987), we named the stimuli in our study “anti-expressions.” Examples of anti-expressions are shown in Figure 1. As the anti-expressions contain equivalent amounts of visual change equivalent to the difference between emotional facial expressions and neutral facial expressions, they are usable as control stimuli for emotional facial expressions in an examination of visual properties.

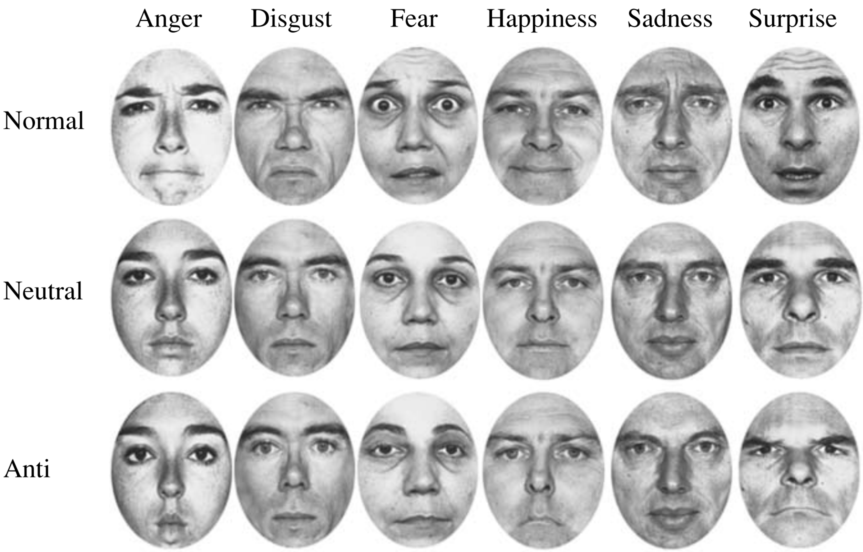


**Figure 1.** Stimulus examples of normal emotional expressions (top), neutral expressions (center), and anti-expressions (bottom). AN = anger; DI = disgust; FE = fear; HA = happiness; SA = sadness; SU = surprise.

If the anti-expressions can be processed as emotionally neutral facial expressions, they could be usable to investigate the effect of emotional significance in emotional facial expressions, controlling the visual features specific to emotional facial expressions relative to neutral expressions. We examined the emotion recognition of anti-expressions in terms of whether or not they could be recognized as emotionally neutral expressions. The original stimuli to make anti-expressions were selected from the standard set of facial expressions of six basic emotions (Ekman & Friesen, 1976). Using the normal emotional expressions and their anti-expressions, we investigated categorical recognition by free responses and dimensional ratings by valence and arousal.

## METHOD

### Participants

Thirty-five undergraduate students (21 females and 14 males; *M* ± *SD* age, 20.3 ± 1.4 years) participated in this study. They were recruited through advertisement. All participants were right-handed, and had normal or corrected-to-normal visual acuity.

### Stimuli

The materials consisted of seven expressions (six basic emotional and one neutral) on models chosen from the Pictures of Facial Affect (Ekman & Friesen, 1976).

We made anti-expressions by using computer morphing techniques (Mukaida et al., 2000) on a Linux computer. First, for the facial images showing emotional and neutral expressions, the coordinates of 79 feature points were identified. The faces were standardized for size and alignment using the information of the coordinates of pupil centers. After this, the metric differences of overall facial features in the emotional and neutral facial expressions were calculated and regarded as 100%. The anti-expressions were made by the –100% transformation of the metric differences. Minor adjustments for pixels were conducted using Photoshop 5.0 (Adobe).

Although all emotional facial expressions in the set were preliminarily used as materials, some resultant anti-expressions had problems. For example, when in some normal expressions the mouth was opened more than the width of lips, there was no opposite direction in which to close the mouth. Two participants, who did not take part in the experiment itself, did a preliminary rating of the naturalness of the stimuli using a 3-point scale of 1 (*unnatural*), 2 (*acceptably natural*), and 3 (*very natural*). Based on these results, the stimuli rated as unnatural were rejected. The selected stimuli are listed in the appendix. The number of anti-expressions for each emotional category was 12 for anger, 8 for disgust, 3 for fear, 4 for happiness, 10 for sadness, and 1 for surprise. The corresponding 37 normal emotional expressions and 14 neutral expressions of the models were also used for the recognition tasks.

Using Photoshop 5.0 software (Adobe), all stimuli were cropped into a circle, slightly inside the frame of the face, to eliminate contours and hairstyles not relevant to the expression. The size of the stimuli was 7 degrees vertically and 5.6 degrees horizontally. Figure 1 presents examples of the stimuli.

### Apparatus

The events were controlled by SuperLab Pro 2.0 (Cedrus) on a Windows computer (MA55J, NEC). The stimuli were presented on a 19-inch CRT monitor

(GDM-F400, Sony) with refresh rate of 100Hz and the resolution of 1024 × 768 pixels. The participants' responses were recorded using a keyboard.

### Procedure

The experiments were conducted individually in a sound-attenuated room. The participant was seated comfortably with her/his head supported by a chin-and-forehead rest, 0.57m from the monitor. Two types of tasks were conducted: free categorical labeling, and dimensional rating with valence and arousal. The order of tasks was randomized.

For free categorical responses, the participants were asked to provide the best emotional description for each stimulus face.

For the dimensional rating, the participants were asked to rate the stimulus faces in terms of emotional valence and arousal (Russell, 1989), on a 9-point scale from 1 (*negative; sleepy*) to 9 (*positive; aroused*). The participants performed several practice trials to familiarize themselves with the procedure.

A total of 176 trials (88 trials for each task) were performed. The order of stimulus presentation was randomized in each task. A short break was interposed after 44 trials in each task, and a longer break was interposed after each task. Although the participants were also asked to rate the stimuli using some other properties, these data are not reported here because they were irrelevant to the purposes of the study.

### Data Analysis

For categorical recognition by free responses, we counted how many times each term appeared. Similar terms were grouped together in one category by referring to the dictionary. The top three categories for each condition are reported.

For dimensional ratings, each rating was analyzed in a two-way analysis of variance (ANOVA) with stimulus type (normal, anti) and emotion (anger, disgust, fear, happiness, sadness, surprise) as within-participant factors. For significant interactions, follow-up simple comparisons were conducted. For dimensional ratings showing the reversal of polarity (e.g., from negative to positive), additional contrasts were conducted for the absolute values from the neutral state (i.e., 5), as the intensity of emotion has been proposed to correspond to the distance from the neutral state (Reisenzein, 1994). The results of all tests were considered statistically significant at $p < .05$.

## RESULTS

### Free Categorical Responses

The three most frequently generated categories in free categorical responses are shown in Table 1. For the normal expressions of all emotions, the categories the stimulus persons intended to express were selected according to the most frequently or the second most frequently given. For the anti-expressions of all emotions except surprise, the most frequently selected category was "neutral." The participants described the anti-expressions of surprise as angry, threatening, or negative.

**TABLE 1**
**THREE MOST FREQUENTLY SELECTED CATEGORIES AND THEIR PERCENTAGE OF FREQUENCY IN FREE RESPONSES**

| | | Normal | | Anti | |
|---|---|---|---|---|---|
| Expression | Order | Category | % | Category | % |
| AN | 1 | Angry | 51.2 | Neutral | 20.2 |
| | 2 | Sad | 5.2 | Sleepy | 5.7 |
| | 3 | Surprised | 4.8 | Discontented | 5.2 |
| DI | 1 | Angry | 26.4 | Neutral | 25.7 |
| | 2 | Disgusted | 18.9 | Happy | 5.4 |
| | 3 | Negative | 12.1 | Sad | 5.4 |
| FE | 1 | Surprised | 54.3 | Neutral | 15.4 |
| | 2 | Fearful | 11.4 | Sleepy | 11.4 |
| | 3 | Angry | 11.4 | Angry | 5.7 |
| HA | 1 | Happy | 73.6 | Neutral | 15.7 |
| | 2 | Calm | 3.6 | Discontented | 10.0 |
| | 3 | Content | 2.1 | Angry | 8.6 |
| SA | 1 | Sad | 43.4 | Neutral | 22.3 |
| | 2 | Embarrassed | 8.0 | Angry | 9.4 |
| | 3 | Disappointed | 4.6 | Happy | 8.0 |
| SU | 1 | Surprised | 85.7 | Angry | 28.6 |
| | 2 | Blank look | 5.7 | Nervous | 14.3 |
| | 3 | Unexpected | 2.9 | Discontented | 11.4 |
| NE | 1 | Neutral | 33.9 | | |
| | 2 | Angry | 4.5 | | |
| | 3 | Sleepy | 4.5 | | |

*Notes:* AN = anger; DI = disgust; FE = fear; HA = happiness; SA = sadness; SU = surprise; NE = neutral.

### DIMENSIONAL RATINGS

The results of dimensional ratings are shown in Figure 2. The configurations for normal emotional expressions were similar to those in previous studies (e.g., Russell, 1997). The configurations for the anti-expressions showed quite different patterns from the corresponding normal expressions.

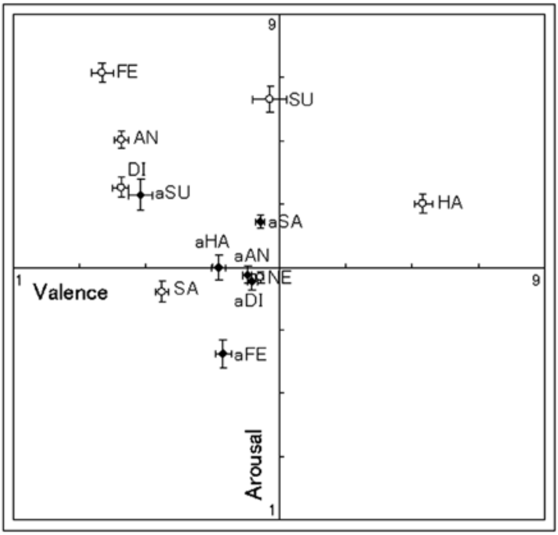


**Figure 2.** Mean (with SEM) ratings for valence (horizontal axis) and arousal (vertical axis). AN = anger; DI = disgust; FE = fear; HA = happiness; SA = sadness; SU = surprise; NE = neutral. The results of anti-expressions are indicated by "a" prefixes, and no prefixes indicate the results of normal expressions.

The ANOVA for the valence ratings revealed a significant interaction of stimulus type × emotion, $F(5,170) = 138.98$, $p < .001$. The main effects of stimulus type and emotion were also significant, $F(1,34) = 23.93$ and $F(5,170) = 117.06$, respectively, *p*s < .001. Follow-up simple effect analyses for the interaction revealed that the simple main effect of stimulus type was significant for anger, disgust, fear, happiness, sadness, and surprise, *F*s(1,204) = 99.34, 108.75, 92.11, 265.35, 61.28, and 105.19, *p*s < .001. For anger, disgust, fear, and sadness, the simple effects indicated that the ratings were less negative for anti-expressions than for normal expressions. For happiness and surprise, which showed the changes of polarities between normal and anti-expressions, additional specific comparisons were conducted for absolute values from the neutral state to investigate the intensity. For happiness, the absolute values were lower for anti-expressions than for normal expressions, $F(1,34) = 77.76$, $p < .001$. For surprise, the absolute values were higher for anti-expressions than for normal expressions, $F(1,34) = 24.97$, $p < .001$.

The ANOVA for the arousal ratings revealed a significant interaction of stimulus type × emotion, $F(5,170) = 71.20$, $p < .001$. The main effects of stimulus type and emotion were also significant, $F(1,34) = 139.46$ and $F(5,170) = 42.06$, respectively, $p$s < .001. Follow-up analyses for the interaction revealed that the simple main effect of stimulus type was significant for anger, disgust, fear, happiness, sadness, and surprise, $F$s(1,204) = 82.26, 40.21, 355.39, 18.48, 22.08, and 41.18, $p$s < .001. For happiness and surprise, the simple effects indicated that the ratings showed less arousal for anti-expressions than for normal expressions. For anger, disgust, fear, and sadness, as the polarities were changed between normal and anti-expressions, additional contrasts were analyzed for absolute values from the neutral state. For anger, disgust, and fear, the absolute values were lower for anti-expressions than for normal expressions, $F(1,34) = 77.00$, 36.44, and 48.87, respectively, $p$s < .001. For sadness, there was no significant difference between the absolute values of anti- and normal expressions, $F(1,34) = 0.01$, *ns*.

## DISCUSSION

The results of this study can be summarized as follows. For the free responses, the anti-expressions were categorized as neutral, which was common to all basic emotions except surprise. For the dimensional ratings, the anti-expressions of almost all emotions were rated as emotionally less intense with regard to both valence and arousal dimensions, although the valence ratings for the anti-expressions of surprise were more negative than those for normal expressions, and the arousal ratings for the anti-expressions of sadness showed no significant difference from the normal expressions. In brief, our results showed that the anti-expressions were recognized as emotionally neutral and rated as less emotional than the normal expressions in the cases of anger, disgust, fear, and happiness.

For the anti-expressions of sadness, the arousal ratings were not less emotional than for those of the normal expressions. However, it must be noted that the arousal ratings for normal expressions of sadness were only slightly distant from the neutral states (less than 1 point), which could induce the flooring of emotional intensity. The results of free categorical responses indicated that the participants recognized the anti-expressions of sadness as neutral facial expressions. Based on these results, we think that the problem of arousal ratings may not be critical for the anti-expressions of sadness.

For the anti-expressions of surprise, the results of free categorical responses and valence ratings showed that they were considered emotional expressions. The participants frequently categorized the anti-expressions of surprise as anger, threatening, or negative, and rated them as extremely negatively valenced. These results are understandable when the characteristics of facial features in the anti-expressions of surprise are considered. In contrast to the normal expressions of surprise, which include raised eyebrows, wide open eyes, and wide open mouths, the anti-expressions of surprise showed lowered eyebrows, narrowed eyes, and tightly closed mouths. These are the typical features of negative emotional expressions such as angry faces (Ekman & Friesen, 1975). We suggest, therefore, that the anti-expressions of surprise are not usable as emotionally neutral control facial stimuli.

With this exception, we propose that, as a group, anti-expressions constitute plausible controls as neutral faces for emotional facial expressions in terms of visual properties, in the case of anger, disgust, fear, and happiness. The anti-expressions of sadness are also usable as emotionally neutral faces, based on free recognition data.

Anti-expressions have practical significance for future investigations. Previous psychological studies have shown that the various types of perceptual and cognitive processes for emotional facial expressions are more effective than those for neutral facial expressions (e.g., Williams et al., 2005). However, it remains to be determined whether this effect is due to the emotional significance or the physical features of emotional facial expressions. Anti-expressions can be used as powerful control stimuli for investigating this issue in future studies.

Our results also have theoretical significance for the relationships between physical properties and the emotional contents of facial expressions. To make the anti-expressions, we changed all facial features of emotional expressions in the opposite direction from the neutral expressions by an amount equivalent to the difference between the emotional and neutral expressions. However, the physical changes in the anti-expressions did not express the emotional messages opposite to the normal emotional expressions. Visual inspection of the configurations in the dimensional ratings suggests that the directions of changes from the normal to anti-expressions appear to be unsystematic. Although some previous studies (e.g., Russell, 1997) have proposed that there is a linear relationship between the physical changes of facial features and the emotional message of facial expressions, our results suggest that this relationship cannot be used as a criterion for changing facial features in the opposite direction. Further investigations with anti-expressions may provide worthwhile topics for more research into the role of facial feature changes in emotion recognition from facial expressions.

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## APPENDIX

The photographs used in this study were chosen from the set in Ekman and Friesen (1976). The ID numbers (and emotional categories) of the stimuli were as follows: A-1-14, C-2-12, GS-2-08, JB-1-23, JM-5-03, MF-2-05, MO-2-11, MO-2-13, NR-2-07, PE-2-21, PF-2-04, and WF-3-04 (anger), EM-4-17, GS-2-25, JB-1-16, JJ-3-20, MO-2-18, PE-4-05, SW-1-30, and WF-3-11 (disgust), EM-5-21, MF-1-26, and MO-1-23 (fear), JJ-4-08, PE-2-06, PF-1-06, and WF-2-11 (happiness), A-2-06, EM-4-24, GS-2-01, JJ-5-05, JM-3-11, MF-1-30, MO-1-30, NR-2-15, PF-2-16, and SW-2-16 (sadness), PE-6-02 (surprise), and A-1-02, C-2-03, EM-2-04, GS-1-04, JB-1-03, JJ-3-04, JM-1-09, MF-1-02, MO-1-05, NR-1-03, PE-2-04, PF-1-02, SW-3-03, and WF-2-05 (neutral).

The Pictures of Facial Affect (Ekman & Friesen, 1976) is available for purchase from **http://www.paulekman.com/**