The interrelationship of recognition of facial expression of the six basic emotions

Atsunobu Suzuki, Takahiro Hoshino, and Kazuo Shigematsu

The University of Tokyo*

An interrelationship in the recognition of facial expressions of the six basic and specific emotions has been inferred from neurological cases who have displayed a disproportionate impairment in recognizing them. The previous reports, however, are vulnerable to the criticism that the apparent emotion-specific impairments are merely artifacts due to the various levels of difficulty in recognizing the different emotions. We propose a new method for the assessment of recognition of facial expression. In this method, the difficulty artifacts are fully controlled by means of morphing and item response theory (IRT). We used a morphing technique to create intermediate facial expressions which would have various levels of difficulty for recognizing each emotion. By using IRT, the sensitivity to the expressions was estimated by taking account of differential difficulty levels. The results revealed that a sensitivity to happiness alone was not correlated with a sensitivity to the other emotions, and indicated that the recognition of happiness was independent.

Key words: facial expression recognition, basic emotions, morphing, item response theory (IRT)

It is well-known from the literature that there is a moderately common, cross-cultural ability to recognize facial expressions which show at least a subset of emotions, the so-called basic emotions: happiness, surprise, fear, anger, disgust, and sadness. The issue of an interrelationship between the recognition of the six basic emotions is controversial. Neuropsychological research reports have indicated that focal brain damage can cause a disproportionate impairment in the recognition of facial expressions of specific emotions, especially fear and disgust. The result suggests that there are neural substrates that are specialized for recognizing certain emotions. A broad deficit in recognizing emotions which are not happiness also indicates a major differentiation between the recognition of happiness and the other emotions. The previous reports, however, have been criticized for a lack of control over the different levels of recognition difficulty across the emotions.

The critics have argued that the apparent emotion-specific impairments are merely artifacts that are due to differential difficulty levels across the emotions.

The present article proposes a new method that is designed to assess the recognition of emotional facial expression as "the sensitivity to basic emotions indicated by facial expressions", or simply "sensitivity scores". In this method, participants are asked to rate the emotional intensity of morphed facial expressions, and their sensitivity scores are estimated by applying item response theory (IRT) to their rating responses. Morphing can provide stimuli with various levels of recognition difficulty for each emotion. An elaborate psychometric measurement of IRT enables the estimation of sensitivity scores, depending both on the rating responses of the participants and on the properties of the stimulus which affect the recognition difficulty (Embretson & Reise, 2000).

In this study, by using the new method, we explored the relationship of recognition of the six basic emotions shown in facial expressions without the confounding factor of difficulty artifacts.

Method

Participants The subjects were 443 undergradu-
ates, of whom 340 were males, with an age range of 18 to 31 years.

**Task and stimuli** The participants were tested together in a large classroom with a large screen at the front. Each of 36 black-and-white photographs of facial expressions was presented on the screen for 25 seconds. During the presentation of each stimulus the participants were asked to rate the emotional intensity of each facial expression with respect to the six basic emotions. The ratings were made on a 6-point scale, from 0 (not at all) to 5 (very much).

Six of the 36 photographs were prototypical images of the six basic emotions, posed by a Japanese woman. Each of the other 30 stimuli were morphed images of two different prototypical photographs. For each of the 15 possible pairs of the six prototypes, two morphs were created by blending in the proportions of 60:40, and vice versa.

The order of the 36 stimuli was quasi-randomized with the constraint that any two images containing the same prototypical expression were not presented consecutively.

**IRT model** The scores of the sensitivity to any specific basic emotion were estimated by applying a graded-response model to the participants' rating responses to 11 facial images containing the corresponding emotion.

**Results**

The IRT estimates of the sensitivity scores showed considerable variability among the participants, and their distributions displayed a unimodal and roughly symmetrical curve for each emotion. This result indicated that the sensitivity scores were not distorted by difficulty factors.

The correlations of the sensitivity scores of each basic emotion are shown in Table 1. The sensitivity scores of the five basic emotions, excluding happiness, were significantly and positively correlated with each other. The sensitivity score of happiness, however, was not correlated with that of any other emotion.

We conducted an exploratory factor analysis to further examine the correlation structure of the six sensitivities. A scree plot revealed that the first factor alone had an outstanding eigenvalue (2.9), when compared to the following factors (0.4-1.0), indicating that a one-factor model was appropriate. The variance explained by the first factor was 40%, and the factor loadings were 0.027 for happiness, 0.770 for surprise, 0.525 for fear, 0.773 for anger, 0.683 for disgust, and 0.697 for sadness. This result meant an almost null factor loading for happiness.

**Discussion**

Analyses of the correlation structure of the sensitivity to different emotions confirmed the independence of a recognition sensitivity for happiness, rather than a complete dissociation/association of recognition sensitivity for each emotion. Although previous studies which reported an independence for the recognition of happiness have been attacked for not controlling difficulty artifacts, the present study appears to have controlled these artifacts successfully, because the distributions of the sensitivity scores are approximately normal. Because happiness is the only completely positive emotion of the six basic emotions, and the others are mostly negative, the finding suggests an orthogonality between positive emotion recognition and negative emotion recognition. It would be desirable to use several other positive emotions in any future research which attempted to establish this orthogonality.

**References**