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# Supplemental Data

# Cultural Confusions Show that

# Facial Expressions Are Not Universal

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## Supplemental Experimental Procedures

### Subject Questionnaire

Each potential observer completed the following questionnaire. We selected only those answering 'no' to all questions for participation in the experiment.

Have you ever:

a) lived in an other-race country (e.g., on a gap year, summer work, move due parental employment)
b) visited an other-race country (e.g., vacation)
c) dated interracially
d) had close other-race friendships
e) been involved with any other-race societies (e.g., university cultural societies)

**Table S1. Categorization Accuracy for Western Caucasian (WC) and East Asian (EA) Observers across All Facial Expressions and Same Race (SR) and Other Race (OR) Face Stimuli**

| | | Neutral | Happy | Surprise | Fear | Disgust | Anger | Sadness | |
|---|---|---|---|---|---|---|---|---|---|
| WC | M(%) | **90** | **98** | **83** | **85** | **90** | **92** | **91** | SR |
| | SE | 2.6 | 1.3 | 4.9 | 3.9 | 5.1 | 2.4 | 3.9 | |
| | M(%) | **85** | **100** | **84** | **90** | **85** | **85** | **86** | OR |
| | SE | 1.4 | 0.3 | 4.2 | 3.4 | 5.2 | 3.7 | 4.1 | |
| EA | M(%) | **95** | **99** | **87** | **58** ** | **71** * | **86** | **92** | SR |
| | SE | 1.7 | 1.0 | 3.2 | 7.3 | 6.1 | 5.5 | 2.4 | |
| | M(%) | **91** | **99** | **94** | **69** ** | **67** * | **74** | **87** | OR |
| | SE | 2.6 | 0.4 | 2.9 | 5.3 | 5.5 | 5.5 | 3.2 | |

*$p < 0.05$; **$p < 0.001$.

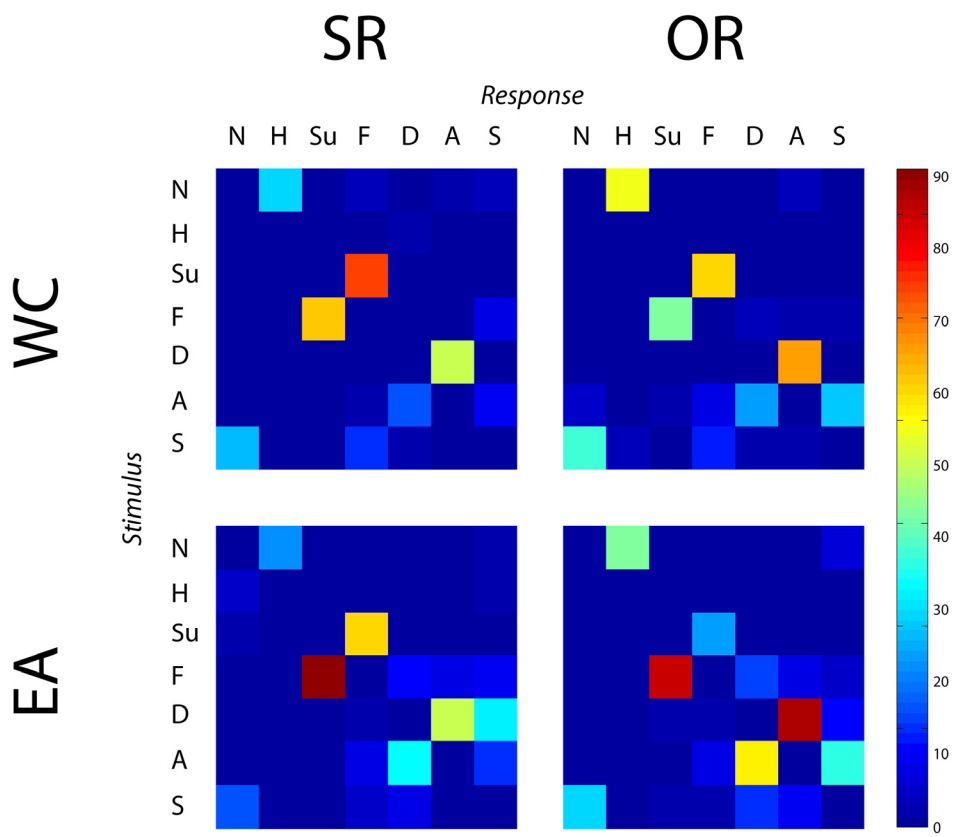


**Figure S1. Confusion Matrices of Categorization Errors for Western Caucasian (WC) and East Asian (EA) Observers for Same Race (SR) and Other Race (OR) Faces**

The color-coded confusion matrices show the number and type of expression mis-categorizations made by WC and EA observers for SR and OR faces. The rows of each matrix correspond to the stimulus expression presented and the columns correspond to the response given by observers (N = 'neutral', H = 'happy', Su = 'surprise', F = 'fear', D = 'disgust', A = 'anger', and S = 'sadness').

**Figures S2–S6. Eye Movement Analysis Conducted across All Conditions of the Experiment (7 Expressions and 2 Races of Face) for Western Caucasian (WC) and East Asian (EA) Observers**

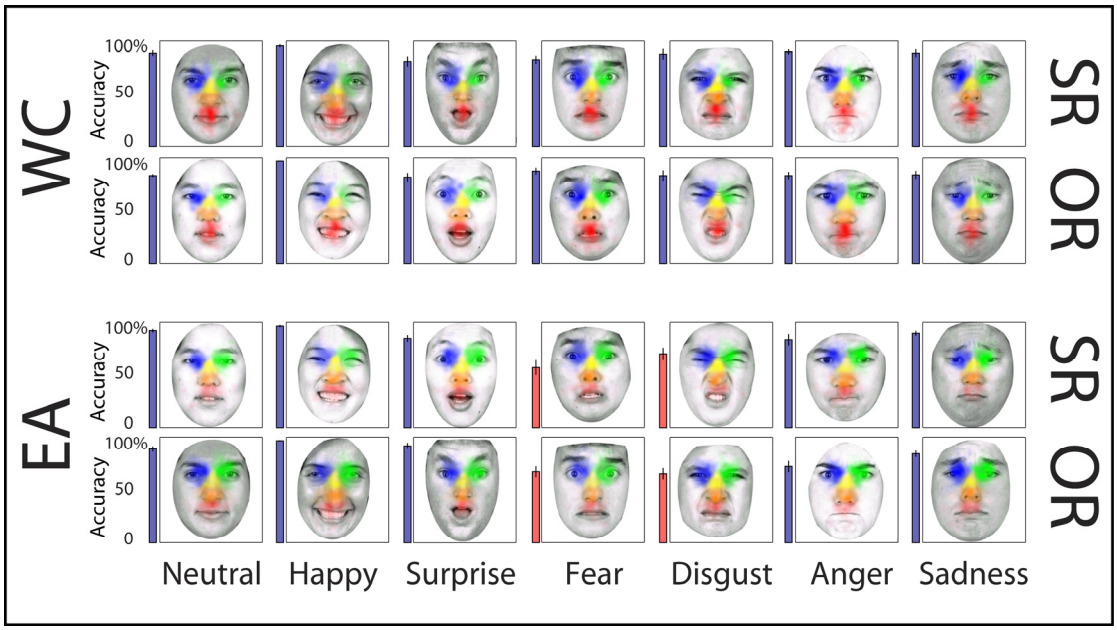


**Figure S2. Fixation Distributions for Each Condition**

Color-coded distributions presented on gray-scale sample stimuli show the relative distributions of fixations across Face regions. Color-coding is as follows: blue – 'left eye', green – 'right eye', yellow – 'bridge of nose', orange – 'center of face', red – 'mouth'. Higher color saturation indicates higher fixation density, shown relative to all conditions. Note that the red 'mouth' fixations for EA observers are less intense compared to WC observers across all conditions, including 'happy'. Color-coded bars represent the mean accuracies for each condition where red indicates a significant difference in categorization errors between observer groups ($p < 0.05$). Error bars indicate standard errors of the mean.

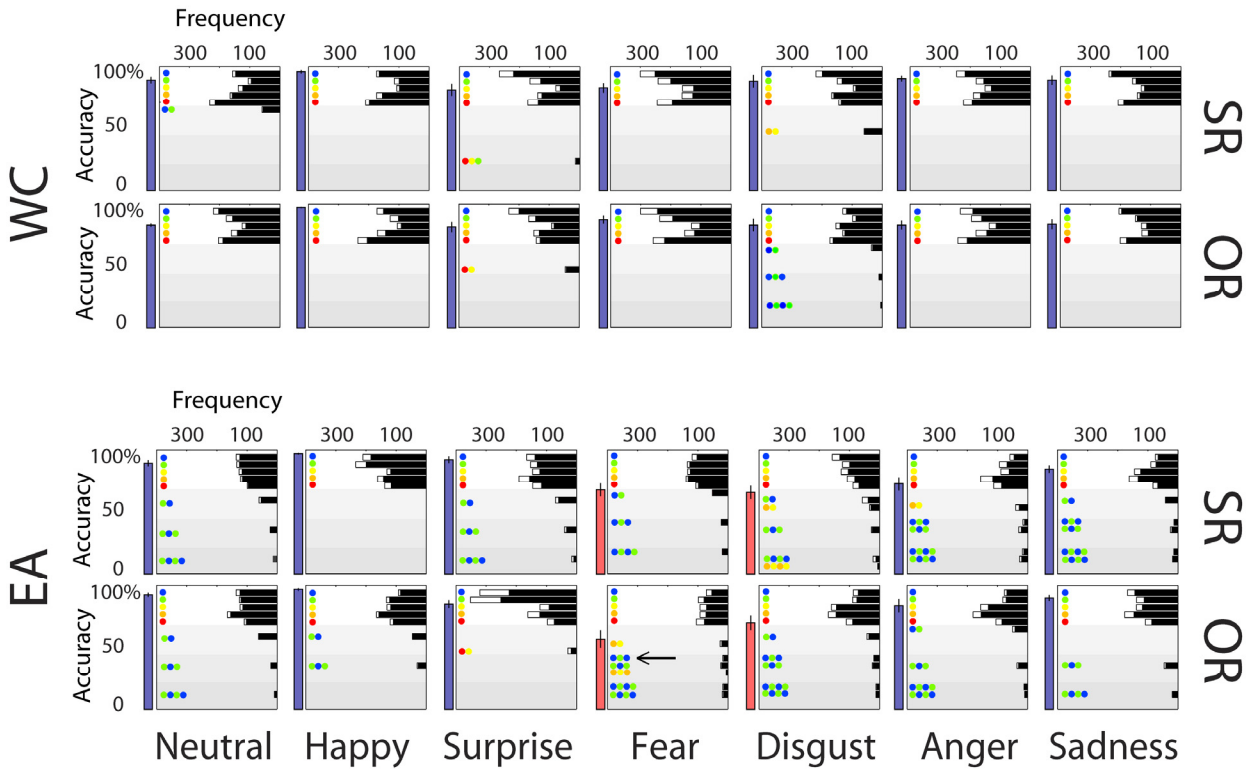


**Figure S3. Minimum Description Length (MDL) – Group Analysis**

Fixation sequences for each condition. Successions of color-coded circles represent the fixation sequences extracted using Minimum Description Length (MDL) analysis with each circle representing a Face region. Face regions are color-coded as follows: blue – 'left eye', green – 'right eye', yellow – 'bridge of nose', orange – 'center of face', red – 'mouth'. For example, the succession of blue - green - blue circles (indicated with a black arrow) corresponds to the fixation sequence 'left eye' - 'right eye' - 'left eye'. Black and white bars to the right of the fixation sequences represent how frequently the fixation sequence appeared in the data set, with black indicating correct trials and white indicating incorrect trials. Different levels of gray in each condition represent the order of the fixation sequences (see Experimental Procedures). Note the higher number of fixations sequences for EA observers compared to WC observers across all conditions. Color-coded bars represent the mean accuracies for each condition where red indicates a significant difference in categorization errors between observer groups ($p < 0.05$). Error bars indicate standard errors of the mean.

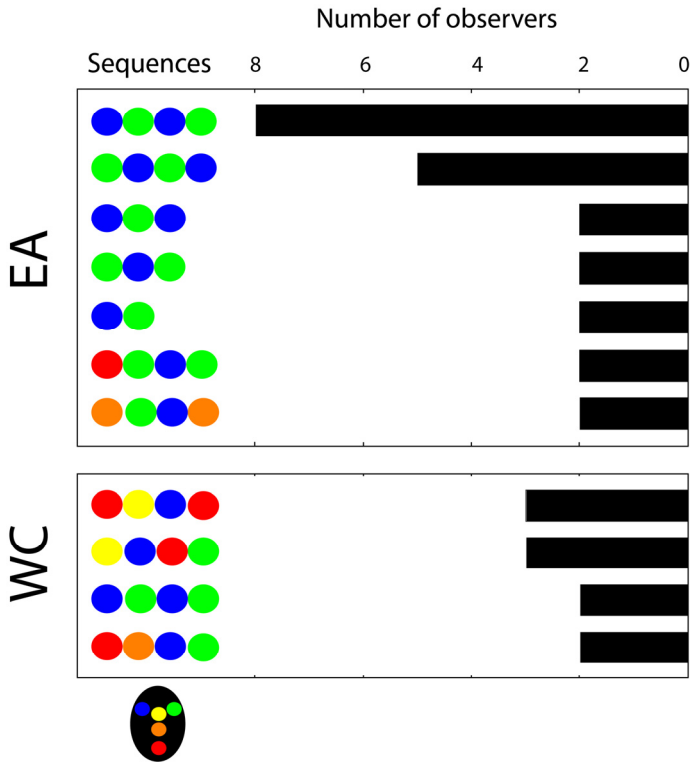


**Figure S4. Minimum Description Length (MDL) – Individual Analysis**

Fixation sequences common across individual observers. To isolate the fixation sequences used by individuals within each observer group, we conducted MDL analysis (see Experimental Procedures) on each individual observer data set separately. Successions of color-coded circles represent the fixation sequences extracted using Minimum Description Length (MDL) analysis. Each circle represents a face region and are color-coded as follows: blue – 'left eye', green – 'right eye', yellow – 'bridge of the nose', orange – 'center of face', red – 'mouth', as depicted in the face above. Black bars appearing to the right of each fixation sequence represent the number of observers using the fixation sequence. Note (1) the higher number of fixation sequences for EA observers compared to WC observers and (2) the more systematic and repetitive use of the eyes for EA observers (i.e. green-blue sequences) compared to WC observers who sample the eyes and mouth equally. This confirms that the persisting fixation sequences to the eyes reported for the EA group of observers was present in a majority of individual observers.

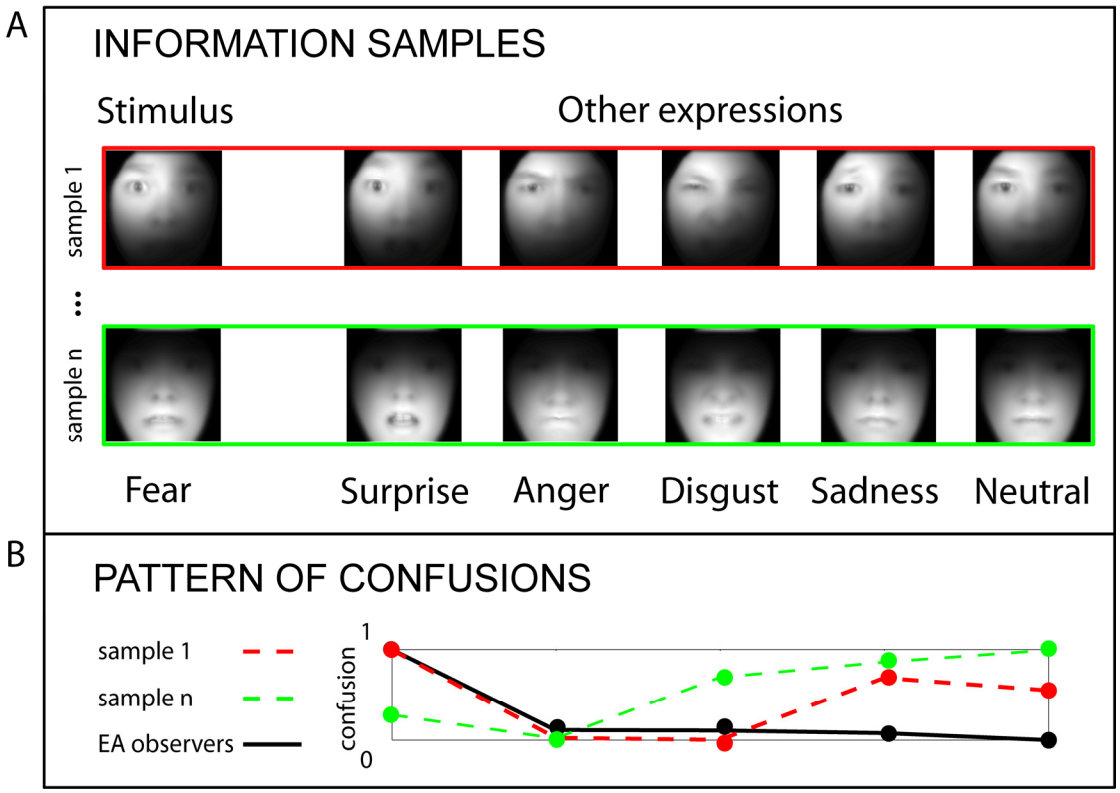


**Figure S5. Model Observer Sampling Method**

Illustration of the procedure to compute estimated patterns of confusion.

(A) Information samples. To compute estimated patterns of confusion, the model sampled face information from the stimulus expression (e.g., 'fear') and from the same location on the other expressions (e.g., 'surprise', 'anger', 'disgust', 'sadness', and 'neutral'). The face images illustrate an example of the information sampled.

(B) Confusion patterns. The model then Pearson correlated the stimulus expression sample with each of the other expression samples. These correlations (plotted in dashed color-coded lines beneath each corresponding face) represented the confusions of the model and were fitted (in a least means squared sense) against the behavioral confusions of the EA observers (plotted in black). The behavioral confusions of the EA observers were obtained by categorizing each incorrect trial by response, for each expression (e.g., for 'fear' trials, the number of incorrect responses were computed for 'neutral', 'surprise', 'disgust', 'anger', and 'sadness'). We repeated the sampling and correlation process for 10,000 individual samples selected randomly across the face and finally sorted each information sample according to its fit to the behavioral confusions of the EA observers ('best' to 'worst' fits are shown in Figure S6). We followed the same procedure for each expression.

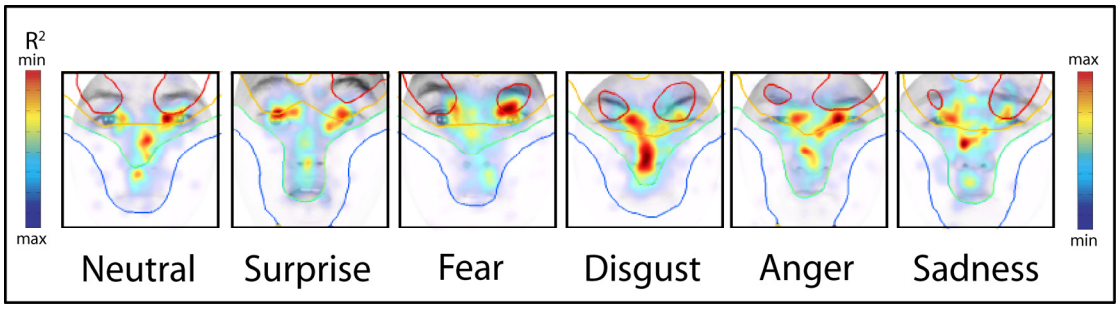


**Figure S6. Model Observer and East Asian Observer Fixation Maps**

Contour Plots: Color-coded lines represent the rank order of information samples according to fit, with red showing the 'best' fit (scale on left).

Fixation Patterns: For each expression, fixations leading to behavioral confusion errors are shown by relative distributions presented on gray-scale sample stimuli. Red areas indicate higher fixation density for each expression (scale on right). Note the higher density of EA observer fixations within face regions ranked as 'best fit' across all expressions, demonstrating that the behavioral confusions of EA observers are due to an information sampling strategy that selects ambiguous information (i.e. the eyes and eyebrows) while neglecting more diagnostic features (i.e. the mouth).