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BRIEF REORT

Internal Representations Reveal Cultural Diversity in Expectations of Facial Expressions of Emotion

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Facial expressions have long been considered the “universal language of emotion.” Yet consistent cultural differences in the recognition of facial expressions contradict such notions (e.g., R. E. Jack, C. Blais, C. Scheepers, P. G. Schyns, & R. Caldara, 2009). Rather, culture—as an intricate system of social concepts and beliefs—could generate different expectations (i.e., internal representations) of facial expression signals. To investigate, they used a powerful psychophysical technique (reverse correlation) to estimate the observer-specific internal representations of the 6 basic facial expressions of emotion (i.e., happy, surprise, fear, disgust, anger, and sad) in two culturally distinct groups (i.e., Western Caucasian [WC] and East Asian [EA]). Using complementary statistical image analyses, cultural specificity was directly revealed in these representations. Specifically, whereas WC internal representations predominantly featured the eyebrows and mouth, EA internal representations showed a preference for expressive information in the eye region. Closer inspection of the EA observer preference revealed a surprising feature: changes of gaze direction, shown primarily among the EA group. For the first time, it is revealed directly that culture can finely shape the internal representations of common facial expressions of emotion, challenging notions of a biologically hardwired “universal language of emotion.”

Keywords: culture, facial expressions of emotion, perception, expectations, internal representations

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One of the most fundamental aspects of human social interaction is the communication of emotions, achieved primarily by the exchange of a set of social signals: facial expressions. With biological and evolutionary origins (e.g., Darwin, 1872; Susskind et al., 2008), facial expressions have long been considered a hardwired human behavior, supporting notions of a “universal language of emotion” (e.g., Izard, 1994; Matsumoto & Willingham, 2009). However, cultural differences in cognition and behavior (see Nisbett & Masuda, 2003, for a review) showing consistent differences in the recognition of facial expression (e.g., Biehl et al., 1997; Ekman et al., 1987; Ekman, Sorenson, & Friesen, 1969; Jack, Blais, Scheepers, Schyns, & Caldara, 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi et al., 2005) and supporting views of cultural accents in facial expression signals (see Elfenbein, Beaupre, Levesque, & Hess, 2007; Marsh, Elfenbein, & Ambady, 2003) challenge the universality hypothesis. With reconciliation of these opposing views still pending, debate continues as to whether facial expressions of emotion are biologically hardwired and universal, or malleable to the influences of culture. Here we address this debate.

How could culture exert such an influence on the production and perception of basic emotion signals? Each culture embraces a specific conceptual framework of beliefs, values, and knowledge, which shapes thought and action. Culture-specific ideologies could exert powerful top-down influences on the perception of the visual environment by imposing particular cognitive styles. For example, individualistic (e.g., Western) cultures could generate tendencies to adopt local feature-processing strategies, whereas collectivist (e.g., East Asian) cultures may promote the use of global processing strategies, as suggested by relative size judgments (Davidoff, Fonteneau, & Goldstein, 2008), categorical reasoning styles (Norenzayan, Smith, Kim, Nisbett, 2002), change blindness sensitivities (Masuda & Nisbett, 2006), and eye movements (Blais, Jack, Scheepers, Fiset, & Caldara, 2008; Caldara, Zhou, & Miellet, 2010; Kelly, Miellet, & Caldara, 2010). By using distinct cognitive processing strategies, observers likely acquire culture-specific perceptual experiences of the visual environment, including facial expression signals.

Similarly, ideological concepts underlying societal functioning (e.g., Triandis, 1989) highlight important cultural differences, which likely influence the production of facial expressions. For

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example, individualistic versus collectivist cultures may adopt different display rules that govern when, how, and to whom emotions are expressed (e.g., Matsumoto, Seung Hee, & Fontaine, 2008), thus diminishing, enhancing, or altering facial expression signals. As a result, cultural differences in the expectations of expressive signals could give rise to the reported cultural confusions (e.g., Biehl et al., 1997; Ekman et al., 1987; Ekman et al., 1969; Jack et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi et al., 2005) when expectations are not met.

With such broad impacts upon social behavior, cognitive processing strategies and visual experience, observers from different cultures likely acquire markedly different internal representations of the environment. It is important to note that internal representations provide predictive information about the world based on previous experience, thus shaping expectations and guiding behavior. For example, even when viewing identical face stimuli, Western Caucasian (WC) and East Asian (EA) observers use culture-specific fixation patterns during face identification (Blais et al., 2008) and facial expression recognition (Jack et al., 2009) tasks. Although culture-specific eye movements reflect cultural specificity in internal representations or cognitive processing styles, they cannot alone directly reveal the information observers expect to see or actually use during facial expression recognition. Yet with no objective method available to accurately access the mind of observers, obtaining direct and detailed evidence of culture-specific internal representations of facial expressions has remained challenging.

Here we address this issue using a powerful reverse correlation (RC) technique to access the "mind's eye" of two culturally distinct observer groups (i.e., WC and EA). For each individual observer, we estimated and analyzed their internal representation of each of the six basic facial expressions of emotion: happy, surprise, fear, disgust, anger and sad. As a result, we captured culture-specific information reflecting both past experience and future expectations of facial expression signals. Our data show that WC and EA observers expect emotion to be expressed using distinct facial signals, supporting views of cultural specificity in emotion communication.

Method

Observers

Two cultural groups of observers participated: WC and EA. The WC group consisted of 15 observers (14 European, one North American, *M* age = 27.3 years, *SD* = 6.4; 8 men, 7 women). The EA group consisted of 15 observers (15 Chinese, *M* age = 23.5 years, *SD* = 2.1; 5 men, 10 women). All EA observers had been born in East Asia, having arrived in a Western country (United Kingdom) for the first time, with an average residence of 1.8 months (*SD* = 2.1) and a minimum International English Language Testing System score of 6.0 (Competent User) at the time of testing. All observers had normal or corrected-to-normal vision, gave written informed consent, and confirmed minimal prior experience with other cultures as assessed by questionnaire (see online supplemental materials). We paid all observers £6 per hour for participating. The University of Glasgow Department of Psychology ethical committee approved the experimental protocol.

Stimuli

Each experimental stimulus consisted of the same background stimulus (a gray-scale, race-, gender-, and emotion-neutral face) superimposed with a different pattern of uniform white noise (see Figure 1, Design for an illustration). To compute the race-, gender-, and emotion-neutral background face, we averaged across eight identities (half female, half EA; Matsumoto & Ekman, 1988) previously cross-culturally verified as neutral (Biehl et al., 1997; Ekman et al., 1987; Ekman et al., 1969; Jack et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi et al., 2005). Prior to averaging, we aligned each neutral face on the eye and mouth positions using Psychomorph software (Tiddeman, Burt, & Perrett, 2001), cropping the final image around the face using Adobe Photoshop CS.

Design and Procedure

On each trial of the experiment, we added white noise to the race-, gender-, and emotion-neutral expression face (see online supplemental materials for additional details). The effect of adding white noise is that it perceptively changes the appearance of the neutral face by altering the face features. For example, consider a trial where adding white noise results in white pixels being added to the white eye region of the neutral face: The eye region now appears more white. Consequently, observers may interpret the stimulus as expressive, because the whites of the eyes correspond to the observer's internal representation of the facial expression "surprise" (see Figure 1, Design). Thus, when the observer categorizes the stimulus as surprise, we capture the information the observer wants to see added to the neutral face to create a facial expression of surprise—in this case, the observer wants to see white pixels added to the eye region to create the characteristic whites of the eyes.

We instructed observers to perform a seven alternative forced choice facial expression categorization task according to the six basic facial expressions of emotion (i.e., happy, surprise, fear, disgust, anger and sad), plus a "don't know" response. Observers each categorized 12,000 such trials, producing a set of white noise templates associated with each subjective categorical judgment, which contains the information the observer wants to see added to the neutral face to create a specific facial expression (see Figure 1, Analysis for color-coded examples: red for sad, green for anger). Observers viewed stimuli (380 × 280 pixels) on a midgray background displayed on a 19-in. (48.26-cm) flat panel monitor. A chin rest ensured a constant viewing distance of 85 cm, with images subtending 4.9° × 6.8° of visual angle. Each stimulus remained visible until the observer responded using a keyboard.

Prior to the experiment, we established familiarity with each of the emotion categories by asking observers to provide correct synonyms and descriptions of each. All observers remained naïve to the neutral nature of the underlying background face throughout testing.

Computation: Estimating Internal Representations of Facial Expressions

For each observer, to estimate the internal representation of each facial expression, we first averaged the set of white noise templates in the relevant category (e.g., "sad" outlined in red) before smoothing with a Gaussian kernel (σ = 3 pixels; see Figure 1, Analysis

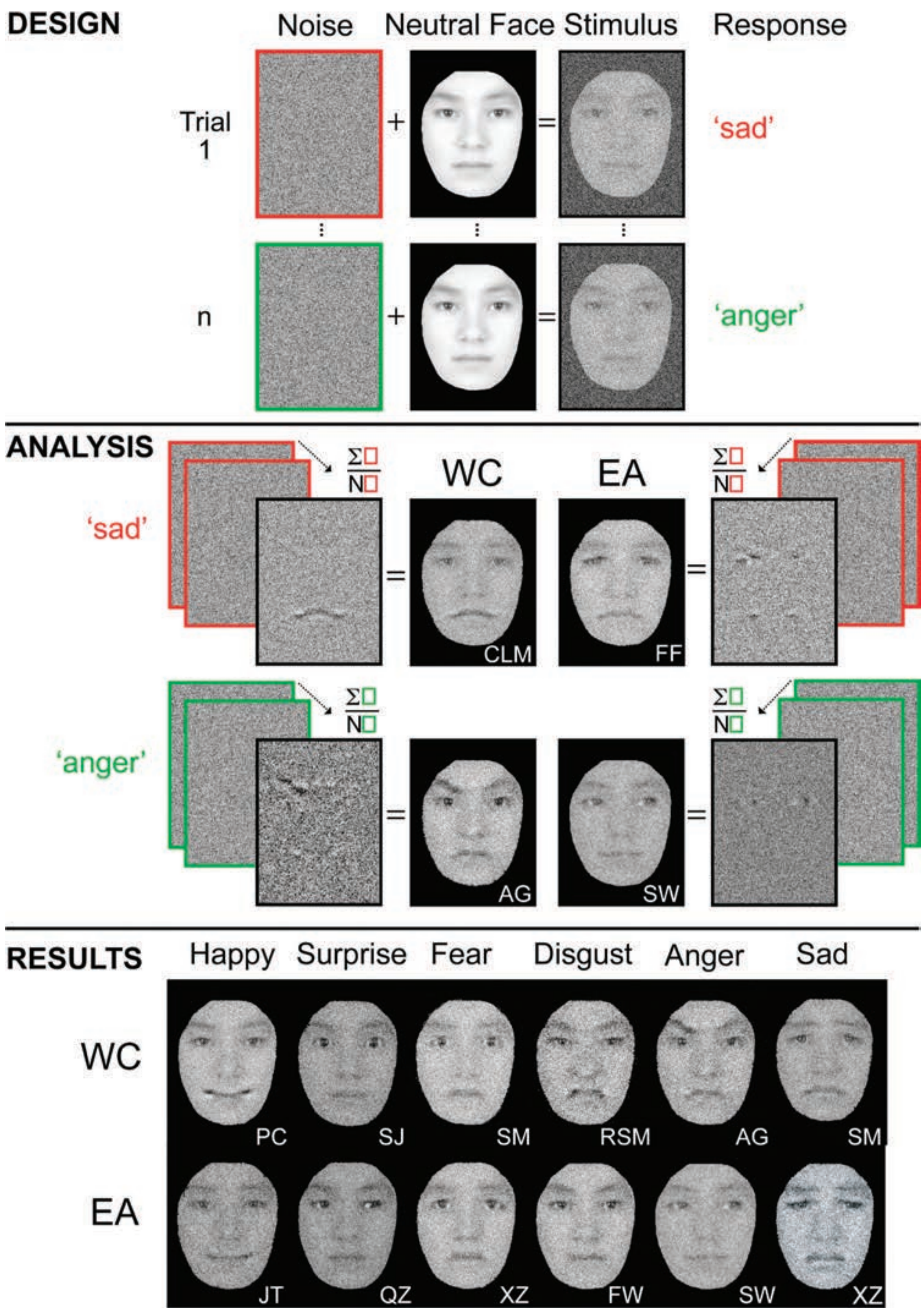

Figure 1. Illustration of the reverse correlation (RC) technique used to estimate observer-specific internal representations. *Design: Stimulus generation and task.* On each trial, we added to a neutral face a white noise. Naïve observers categorized each stimulus according to the six basic facial expressions of emotion (i.e., happy, surprise, fear, disgust, anger, and sad), plus a "don't know" response. *Analysis: Reconstruction of cultural internal representations.* For each observer and facial expression separately, we averaged the set of noise templates associated with the observer's categorization responses (e.g., sad color-coded in red and anger color-coded in green) to reconstruct their internal representation. Averaged noise templates are outlined in black and illustrated for two expressions: sad for Western Caucasian (WC) observer CLM and East Asian (EA) observer FF and anger for WC observer AG and EA observer SW. *Results: Cultural internal representations.* Each row represents the cultural internal representations of the six basic facial expressions of emotion (i.e., happy, surprise, fear, disgust, anger, and sad) estimated using RC. Each internal representation is selected from a different observer (i.e., labeled in capital letters for WC observers and EA observers) and is presented to illustrate the effectiveness of the RC technique.

for an illustration). This averaged white noise represents the changes in gray-level pixel values that, when added to the neutral face, lead the observer to perceive an emotions. To visualize the internal representations, we then added the averaged white noise to the neutral face (see Figure 1, Analysis for examples). As a result, each internal representation shows the features the observer expects to constitute a particular facial expression. For example, as shown in Figure 1, Analysis, the internal representation of sad for WC observer CLM contains a down-turned mouth, whereas for EA observer FF, the internal representation clearly contains changes in the eye region. To isolate the significant pixels for further analysis (not shown in Figure 1), we applied a statistical threshold ($p <$ .05; Chauvin, Worsley, Schyns, Arguin, & Gosselin, 2005) after *Z*-scoring the averaged noise template. The strength of this RC technique is that it flexibly reconstructs internal representations that are free from potential limitations imposed by prescribed stimuli (see Gosselin & Schyns, 2003; Kontsevich & Tyler, 2004, for examples of the application of the current RC technique; see Gosselin & Schyns, 2004; Murray & Gold, 2004, for a comparison with other RC techniques that isolate information required for categorization).

Computation: Statistics Over Facial Features

Classification image techniques are powerful because they estimate internal representations of information, for each individual observer. Here we wish to extract an estimate of how culture modifies internal representations across individual observers. First, we established five face regions of interest (i.e., left eyebrow, right eyebrow, left eye, right eye, and mouth) because, at the level of individual observers, most statistically significant pixels were represented in these regions (78.4% and 70.8% of significant pixels for WC and EA observers, respectively). For each observer and expression independently, we established a threshold number of significant pixels ($\partial \geq 10$) for each region of interest. We determined a hit for this region if the considered internal representation reached the threshold. Finally, for each expression independently, we counted the number of observers in each cultural group who had a hit, in each of the separate five face regions. Thus, for each face region, we examined how culture shapes the representation of expressive information over the face.

Results

To analyze cultural differences, we compared the number of WC and EA observers representing features in each of the face regions of interest—specifically, left eyebrow, right eyebrow, left eye, right eye, and mouth. Chi-square tests of association revealed consistent cultural preferences across all six facial expressions ($p < .05$). Figure 2 illustrates the results for each facial expression using color-coded regions to indicate cultural preferences (red indicates a strong WC preference; blue indicates a strong EA preference, with a maximum of 15 observers in one group reconstructing a face feature vs. zero observers in the other group).

As shown in Figure 2 (top row), WC internal representations featured the eyebrows and the mouth significantly more than in EA representations. In contrast, EA representations (see Figure 2, bottom row) primarily featured the eyes in comparison with WC observers. These differences contradict the universality hypothesis, which predicts reconstruction of similar features across cultural groups and instead supports theories of cultural differences in facial expression signals.

Further inspection of the data revealed another intriguing cultural difference: changes of gaze direction, shown primarily in the EA group. Although not pervasive across the group, changes of gaze direction nevertheless emerged as a strong feature among EA observers, as suggested by literature (e.g., Knapp & Hall, 2005), therefore validating our methods to reveal cultural differences. Figure 3 shows all such internal representations showing changes of gaze direction.

Validation of Internal Representations

The RC technique used here estimates observer-specific internal representations by adding random features to a neutral face via the addition of white noise. Given that the white noise added to the neutral face is unstructured (i.e., each pixel value is random and

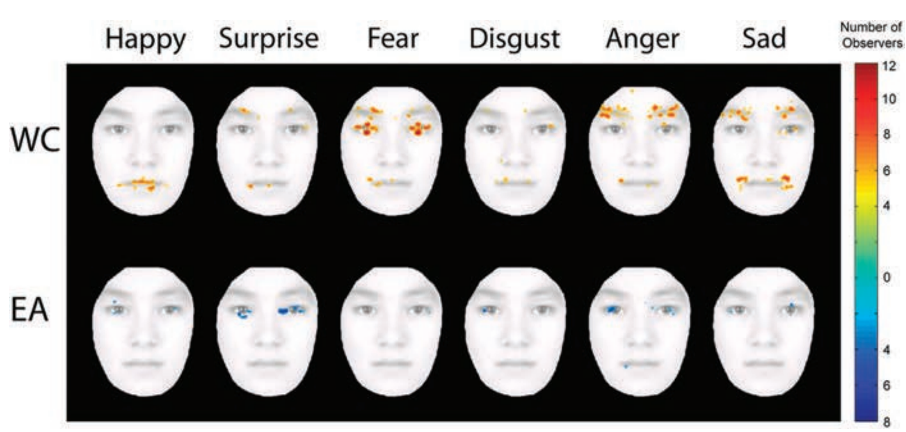

Figure 2. Cultural differences in expressive features. In each row, color-coded areas show cultural preferences in the reconstruction of features for each facial expression of emotion. Magnitude of bias (i.e., absolute difference in the number of observers) is represented by color-coded bars in each row. For example, for surprise the eyes appeared in the internal representations of eight more East Asian [EA] observers than Western Caucasian [WC] observers.

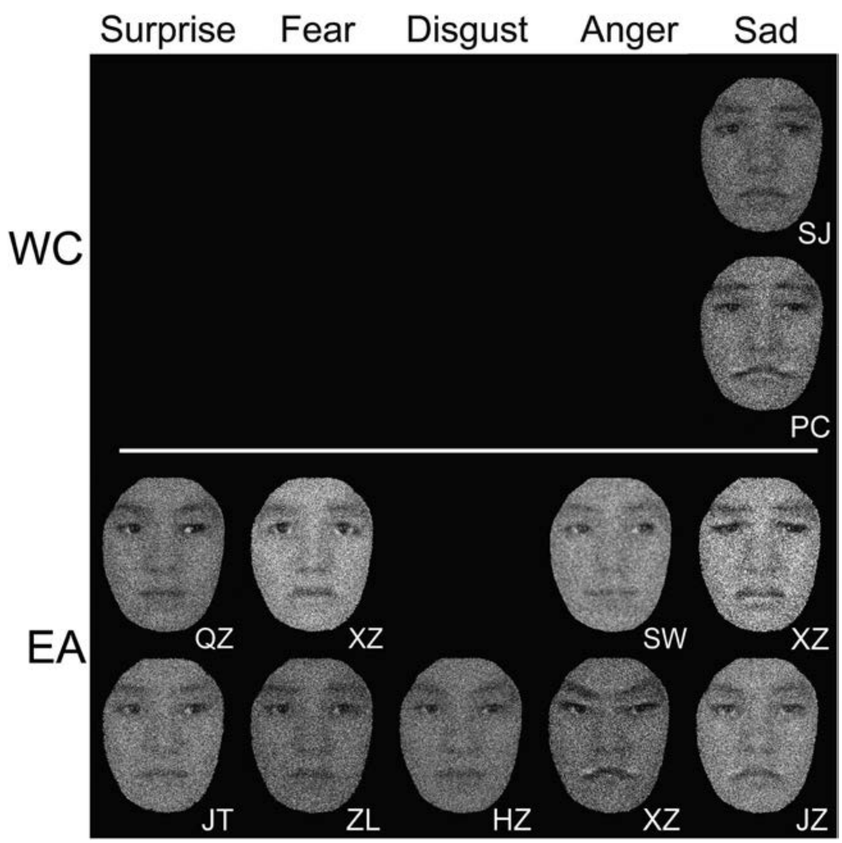

Figure 3. Internal representations showing changes of gaze direction. Each face demonstrates the use of changes of gaze to communicate emotion. Each example is selected from a different observer (initials labeled in capital letters) from the Western Caucasian [WC] and East Asian [EA] groups. Whereas nine EA internal representations showed changes of gaze, only two WC internal representations displayed changes of gaze. Note that for the EA group, changes of gaze direction feature in a wider range of emotions (i.e., surprise, fear, disgust, anger, and sad) compared with the WC internal representations (i.e., sad only).

independent) and contains no features per se (e.g., smiling mouth), the current RC technique could lack the specificity to capture accurately the features of internal representations, resulting in low validity. Here, we randomly subsampled the original WC and EA observers to validate their own internal representations.

Method

Observers. Ten observers from each original cultural group participated (WC = 10 European, *M* age = 26.1 years, *SD* = 5.1, 4 men, 6 women; EA = 10 Chinese, *M* age = 23.8, *SD* = 2.2, 2 men, 8 women). All observers gave written informed consent, received £6 per hour for participating, and remained naïve to the (observer-specific) nature of the stimuli throughout testing. The University of Glasgow Department of Psychology ethical committee approved the experimental protocol.

Stimuli. For each observer, we generated a single set of six stimuli, where each stimulus depicted the observer's own internal representation of happy, surprise, fear, disgust, anger, and sad. To create each stimulus, we used the reconstruction methods described previously (see the Computation: Estimating Internal Representations of Facial Expressions section and Figure 1, Analysis for an illustration).

Design and procedure. We presented stimuli simultaneously in a single randomly ordered row on a computer monitor. Stimuli remained visible as long as observers wished. Observers categorized each stimulus according to the six basic facial expressions of emotion (i.e., happy, surprise, fear, disgust, anger, and sad) by writing down the expression name corresponding to each stimulus.

Results

Analysis of recognition performance showed high accuracy, with observers categorizing 94.2% of all reconstructed internal representations correctly (WC = 100%, EA = 88.33%). Table 1 shows the percentage of internal representations accurately categorized for each emotion category and cultural group of observers. Note that observers correctly categorized 88.9% of the internal representations displaying changes of gaze (see Figure 3 for examples).

Validation of Internal Representations Showing Changes of Gaze

To verify objectively the number of internal representations showing changes of gaze, we conducted a validation task using a different set of WC and EA observers.

Table 1
Percentage Accuracy for Western Caucasian (WC) and East Asian (EA) Observers Categorizing Their Own Internal Representations of the Six Basic Facial Expressions of Emotion

Group	Happy	Surprise	Fear	Disgust	Anger	Sad
WC	100	100	100	100	100	100
EA	100	100	80	80	80	90

Method

Observers. Twenty-two observers participated: 11 WC (11 European; 5 women, 6 men; M age = 24.09 years, SD = 5.61) and 11 EA (11 Chinese, 5 women, 6 men; M age = 24.09 years, SD = 3.08). All EA observers had been born in East Asia, having arrived in a Western country (United Kingdom) for the first time, with an average residence of 4.5 months (SD = 1.03) duration and a minimum International English Language Testing System score of 6.0 at the time of testing. All observers had normal or corrected-to-normal vision, gave written informed consent, and were paid £6 per hour for participating. The University of Glasgow Department of Psychology ethical committee approved the experimental protocol.

Stimuli. To create the stimuli, we reconstructed all internal representations (i.e., 2 Culture of Observers $\times$ 6 Facial Expressions of Emotion $\times$ 15 Observers) using the same methods described previously (see the Computation: Estimating Internal Representations of Facial Expressions section and Figure 1, Analysis for an illustration).

Design and procedure. Observers performed a five alternative forced choice categorization task by categorizing each stimulus according to five gaze directions (i.e., up, down, left, right, and center). Observers viewed stimuli (8.5cm $\times$ 6.75cm) on a midgray background displayed on a 19-in. (48.26-cm) flat panel monitor. A chin rest maintained a constant viewing distance of 77 cm, with images subtended 6.31° $\times$ 5.05° of visual angle. We repeated each stimulus five times and presented stimuli in random order. Stimuli remained visible until observers responded using a keyboard.

Results

To identify the internal representations showing changes of gaze, we compared the total number of responses for each gaze direction (i.e., up, down, left, right, or center), collapsed across all observers, for each stimulus independently. Chi-square tests of association revealed a marked cultural contrast: Nine EA internal representations showed significant changes of gaze, compared with only two WC internal representations ($p < .0001$). Figure 3 shows each of the internal representations showing changes of gaze—note that for the EA internal representations, changes of gaze feature in a wider range of emotions (i.e., surprise, fear, disgust, anger, and sad), compared with the WC internal representations (i.e., sad). For each internal representation showing a change of gaze, WC and EA observers responded equally within the significant gaze category, thus validating all changes of gaze across both cultural groups.

Together, these results demonstrate both the validity of our RC technique to accurately capture internal representations and the ecological validity of the culture-specific facial expression signals reported here, including surprising changes of gaze.

Discussion and Conclusion

Using templates of white noise, we randomly added features to a race-, gender-, and emotion-neutral face and instructed observers from two cultural groups to categorize each image by facial expression. We then reconstructed the internal representations of each facial expression of emotion in each individual observer from both cultural groups. Using statistical image-processing analyses to examine the properties of each internal representation, we revealed clear cultural differences in the facial expression signals expected by each cultural group. Specifically, whereas WC internal representations distributed expressive features across the face (e.g., the eyebrows and mouth), EA internal representations showed a consistent preference for the eyes. Further inspection of the EA eye region preference revealed a surprising feature among the EA group: changes of gaze direction.

To interpret our results, it is important to consider what an internal representation represents. Created from observer-specific experiences, internal representations provide predictive information about the environment, guiding thought and action. Thus, by reconstructing the internal representations of facial expressions in individual observers, we captured information that reflects both past experiences and future expectations of emotion communication.

Cultural specificity in the internal representations of facial expressions shown here may reflect differences in the experience of facial expression signals across cultures. As predicted by culture-specific display rules and accents (Elfenbein et al., 2007; Marsh et al., 2003), modulations in the production of facial expressions could give rise to the differences in the reported internal representations, demonstrating cultural diversity in emotion signals. Contrary to notions of a universal language of emotion, ecologically valid representations of facial expressions would include expressive features characteristic of the culture. For example, we show that observers within the EA group expect changes of gaze to be a component of facial expressions, which does not currently feature in widely used facial expression stimuli (e.g., Matsumoto & Ekman, 1988). Furthermore, although modulations in gaze play a social role in revealing sources of attention (see Kingstone, 2009; Klein, Shepherd, & Platt, 2009, for reviews), we show that gaze direction plays a wider role in social interaction by reflecting internal emotional states.

Correspondence between the location of expected expressive features and culture-specific fixations patterns (Jack et al., 2009) highlights the role of top-down factors on biological visual systems used to select information for categorization, which could give rise to differential perceptual experiences of facial expressions across cultures. Yet eye movements can show where (on the face) fixations are directed but cannot alone reveal the information actually used or expected for emotion categorization. We significantly expand on previous eye-movement studies (e.g., Jack et al., 2009) by reconstructing the specific information the visual system seeks to extract for accurate categorization of facial expressions. Together, eye-movement data and techniques that isolate the information used for categorization (i.e., RC) can more accurately identify the information used for social interaction.

Finally, culture-specific expectations of facial expression signals likely contribute to consistent cultural differences in the recognition of universal facial expressions (e.g., Biehl et al., 1997; Ekman et al., 1987; Ekman et al., 1969; Jack et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi et al., 2005), as information conflicting with internal representations would generate confusion. Moreover, culture-specific fixation patterns used during facial expression recognition (Jack et al., 2009; see also Yuki, Maddux, & Masuda, 2007) would further hinder the process by subsampling culturally incongruent facial expression signals.

In sum, our data directly show, for the first time, differences in the expectations of facial expression signals across diverse cultures, challenging notions of a universal language of emotion and revealing a source of potential confusion during cross-cultural communication.

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