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Abstract

There is a growing consensus that culture influences the perception of facial expressions of emotion. However, relatively few studies have examined whether and how culture shapes the *production* of emotional facial expressions. Drawing on prior work on cultural differences in communication styles, we tested the prediction that people from the Netherlands (a low-context culture) produce facial expressions that are more distinct across emotions compared to people from China (a high-context culture). Furthermore, we examined whether the degree of distinctiveness varies across posed and spontaneous expressions. Dutch and Chinese participants were instructed to either pose facial expressions of anger and disgust, or to share autobiographical events that elicited spontaneous expressions of anger or disgust. Using a supervised machine learning approach to categorize expressions based on the patterns of activated facial action units, we showed that both posed and spontaneous facial expressions of anger and disgust were more distinct when produced by Dutch compared to Chinese participants. Yet, the distinctiveness of posed and spontaneous expressions differed in their sources. The difference in the distinctiveness of posed expressions appears to be due to a larger array of facial expression prototypes for each emotion in Chinese culture than in Dutch culture. The difference in the distinctiveness of spontaneous expressions, however, appears to reflect the greater similarity of expressions of anger and disgust from the same Chinese individual than from the same Dutch individual. The implications of these findings are discussed in relation to cross-cultural emotion communication, including via cultural products.

Keywords

culture, facial expressions, emotion, posed, spontaneous

Emotional communication via facial expressions rests on the production (encoding) and perception (decoding) of emotional expressions (Scherer et al., 2011; Van Kleef, 2016). The extent to which emotional facial communication is universal versus culturally specific is a contentious issue. Most

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of the research on cultural influences in emotional facial communication to date has focused on emotion perception—the act of inferring an expresser's emotion based on physical properties of the expression. Early research suggested that the perception of expressions of at least some emotions is highly similar across cultures, such that people from different cultures perceive similar emotions from facial expressions (e.g., Ekman, 1973; Izard, 1994). More recent research has uncovered cultural differences in the more intricate patterns of emotion perception (Elfenbein & Ambady, 2002), including in the degree to which people perceive mixed emotions in expressions (Fang et al., 2018, 2019; Kayyal & Russell, 2013), suggesting that there are differences in how people from different cultures interpret emotional facial expressions.

In contrast to the substantial literature on cultural influences on emotion perception, relatively few studies have examined the extent to which culture shapes the *production* of emotional facial expressions—the act of expressing a particular emotion by producing physical cues in the face. Moreover, the work that has been conducted on emotion production has focused primarily on posed expressions, that is, deliberately producing an expression in order to attempt to convey a particular emotion (e.g., Elfenbein et al., 2007). Little research has examined spontaneous expressions that occur involuntarily and naturally during interactions (Hess et al., 2016; Schaefer et al., 2010). Here, we sought to investigate how culture shapes both posed and spontaneous facial expressions.

Posed Versus Spontaneous Facial Expressions Across Cultures

Previous research has suggested differences between posed and spontaneous expressions (Hunt, 1941; Krumhuber et al., 2021; Matsumoto et al., 2009a). It has been proposed that posed facial expressions lack facial muscle movements that do occur in spontaneous expressions and/or contain extraneous facial muscle movements that do not occur in spontaneous expressions (Matsumoto et al., 2009b). Empirical work based on Western samples has shown that posed expressions are more intense and prototypical than spontaneous expressions (Tcherkassof et al., 2007). However, no study has compared the production of posed and spontaneous facial expressions in a cross-cultural setting. The extent to which culture influences posed and spontaneous expressions is thus unclear.

Studies of the facial expressions of blind individuals provide some suggestive evidence that posed expressions may be affected by culture to a higher degree than spontaneous expressions. Early observational studies found that congenitally blind individuals produced similar spontaneous facial expressions to those of sighted individuals, while considerable differences between blind and sighted individuals were found for posed expressions (Freedman, 1964; Thompson, 1941). Those results are consistent with later studies that employed standardized measurements of facial muscle movements (Galati et al., 1997; Matsumoto & Willingham, 2009; Rinn, 1991). It has been argued that the differences between posed and spontaneous facial expressions may reflect differential effects of learning processes. Specifically, posed expressions may be affected by social learning of culturally shaped prototypes to a greater degree than spontaneous expressions (Matsumoto & Willingham, 2009; Rinn, 1991).

However, empirical studies of the recognition of emotional expressions suggest that culture-specific learning processes can also shape spontaneous expressions (Crivelli et al., 2017; Kayyal & Russell, 2013; Naab & Russell, 2007; Nelson & Russell, 2013). For instance, when classifying spontaneous facial expressions produced by individuals from Papua New Guinea, fewer than 30% of participants from America and Palestine selected the predicted emotion label (Kayyal & Russell, 2013). Even with other residents from Papua New Guinea, only between 13% and 38% of respondents selected the predicted emotion label (Crivelli et al., 2017). This agreement is far below 70% to 90%, a criterion previously used to support the claim of universality of facial expressions of emotion (Haidt & Keltner, 1999). Other studies have also documented that the recognition of

spontaneous facial expressions varies across emotions as well as cultures (Kayyal & Russell, 2013; Matsumoto et al., 2009a). Past research on emotion perception thus points to cross-cultural variability in spontaneous facial expressions.

Although the perception and production of emotion are different processes, they are both part of the process of communicating emotions (Scherer et al., 2011). We thus expected that evidence from both processes—perception and production—would shed complementary light on the role of culture in emotional facial communication. While the limited evidence on the production of emotional facial expressions seems to suggest that culture has a small, or even negligible, impact on spontaneous compared to posed expressions, evidence from studies on emotion perception points to a role for culture in the perception of spontaneous facial expressions. We thus included both posed and spontaneous expressions in the same study and examined how culture shapes the production of posed versus spontaneous facial expressions.

Emotional Facial Communication Across Cultures

Individuals from different cultures differ in how they communicate with each other, driven in part by the degree of historical heterogeneity in a society (Gudykunst et al., 1996; Hall, 1976; Niedenthal et al., 2019). Populations of historically homogeneous societies (including countries such as China and Japan) originate from one or a few source countries. They have common values and beliefs (Mesquita & Frijda, 1992), and are usually characterized by stable and predictable interpersonal relationships. In historically homogeneous societies, a lot of information is conveyed by the physical context in conjunction with a shared understanding of reality, and comparatively less information is embedded in the explicit part of the message, a style referred to as "high-context communication" (Hall, 1976). Consequently, communication in homogeneous societies is more indirect and ambiguous (Gudykunst & Ting-Toomey, 1988). In contrast, historically heterogeneous societies (including countries such as the United States and the Netherlands) have populations who originate from many source countries, and contain diverse values and beliefs brought in from their cultures of origin. To navigate such diverse social worlds, individuals need to convey their feelings and intentions directly and precisely, a style referred to as "low-context communication" (Hall, 1976). The communication in heterogenous societies is thus more direct and specific (Gudykunst & Ting-Toomey, 1988).

We propose that these cultural differences in communication styles, and especially the greater specificity of expression in historically heterogeneous cultures compared to homogenous cultures, might also be evident in the production of emotion expressions. Because much information is embedded in the context in high-context cultures, people can rely on these cues for emotional communication. As a result, people in homogeneous cultures may produce emotional facial expressions that are made up of less distinctive patterns of facial muscle movements compared to people in heterogeneous cultures. Such lower distinctiveness of facial muscle movements can derive from (a) smaller differences between one individual's facial expressions of different emotions and/or (b) larger differences between different individuals' expressions of the same emotion. In the former manifestation, an individual from a homogeneous culture would use more similar facial movements to express different emotions compared to an individual from a heterogeneous culture. In the latter manifestation, individuals from homogeneous cultures would exhibit larger differences in how they express the same emotion compared to individuals from homogeneous cultures.

Notably, regardless of whether lower distinctiveness is due to smaller differences between one individual's expressions of different emotions and/or larger differences in the ways in which different people express the same emotion, less distinctive emotional facial expressions should be more challenging to decode. We thus expected that facial expressions of emotions would be more difficult to identify when they are shown by individuals from homogeneous as compared to heterogeneous

cultures. Two previous studies provide suggestive evidence consistent with this possibility. Wood et al. (2016) reanalyzed the results of 92 studies reporting a total of 212 average cross-cultural emotion recognition scores, and found that individuals from historically heterogeneous cultures produce facial expressions of emotion that are recognized more accurately than expressions produced by individuals from homogeneous cultures. In another study, Rychlowska et al. (2015) showed that people from heterogeneous countries believe that they should freely express or even amplify emotional expressions, whereas people from homogeneous countries tend to think they should dissimulate emotional expressions. These arguments are further bolstered by a recent review on historical heterogeneity and emotion communication that suggests that historically heterogeneous societies promote expressivity and clarity in emotional expressions (Niedenthal et al., 2019).

These findings provide novel insights into how culture might influence the distinctiveness of emotional communication. However, these studies examined emotion production by analyzing subjective reports of social norms or perceptual judgments of expressions, which cannot fully exclude the influence of perceiver-level characteristics and its interactions with expresser-level characteristics. Arguably the most direct and valid way of examining facial expressions produced by individuals from homogeneous versus heterogeneous cultures is to measure their actual patterns of facial expressions of emotions. Therefore, in the present study, we recruited Dutch and Chinese individuals, who are from historically heterogeneous and homogeneous cultures respectively (Niedenthal et al., 2019; Rychlowska et al., 2015; Wood et al., 2016), and analyzed their facial muscle movements as they produced posed or spontaneous facial expressions of emotions. In order to test whether emotional expressions are more distinct when they are shown by Chinese relative to Dutch people, we used a machine learning approach as an analogy to a completely naïve observer (who has no knowledge about prototypes of emotional expressions and no cultural background), to categorize expressions based on the patterns of action units (AUs). AUs refer to visually distinguishable and anatomically based units of facial muscle movements as described by the Facial Action Coding System (FACS; Ekman et al., 2002). Our hypothesis would be supported if the machine learning model is more accurate in categorizing facial expressions of Dutch as compared to Chinese participants.

Here, we focused on facial expressions of two emotions: anger and disgust. These emotions were selected based on three reasons. First, anger and disgust are widely held to be basic emotions (Ekman, 1992; Izard, 2007) and would thus be expected to occur in both Chinese and Dutch cultures. Second, although anger and disgust are distinct emotions, they are conceptually related (Giner-Sorolla et al., 2018) and associated with morphologically similar facial configurations (Cordaro et al., 2018; Susskind et al., 2007). Examining emotional expressions that show partial overlap in their facial morphology (rather than expressions that are entirely different, e.g., anger and happiness) allows for a meaningful test of the effects of culture on expressive distinctiveness (effects of culture on the distinctiveness of emotion expression, if they exist, are less likely to manifest in comparisons between anger and happiness). Third, recent studies have found that Westerners are more likely to perceive specific emotions in facial expressions of anger and disgust, whereas Easterners tend to perceive mixed emotions in these facial expressions (Fang et al., 2018, 2019). We predicted that this inclination may also become manifest in the *production* of facial expressions of anger and disgust, with Westerners' facial expressions of anger and disgust being more distinct than Easterners' facial expressions of these emotions. Examining anger and disgust thus allows for direct comparisons of cultural influences on emotion production in the current research with cultural influences on emotion perception observed in previous work (Fang et al., 2018, 2019).

The Present Research

In the present study, we instructed Dutch and Chinese participants to pose facial expressions of anger and disgust with the goal of being understood by their friends (*posed* facial expressions), and another group of Dutch and Chinese participants to share autobiographical events that had

elicited feelings of anger or disgust (*spontaneous* facial expressions). To examine the distinctiveness of the emotional expressions, we coded all facial expressions using the FACS (Ekman et al., 2002), and then used a machine learning approach to categorize expressions based on the patterns of AUs. Based on prior theoretical and empirical work, we expected that Dutch participants would produce more distinct emotional expressions than Chinese participants. As a result, the machine learning model would be more accurate in categorizing facial expressions of Dutch relative to Chinese participants.

In an attempt to distinguish between the two sources of distinctiveness (smaller intra-individual variance in the expression of different emotions vs. larger inter-individual variance in the expression of the same emotion), we isolated the role played by intra-individual similarities, as calculated using the Hamming distance between facial expressions of anger and disgust for each individual. If no differences in Hamming distance were found between Chinese and Dutch facial expressions, then the lower distinctiveness in Chinese expressions (if found to exist) would be more likely to reflect their greater inter-individual differences when expressing a given emotion. If, however, significant differences in Hamming distance were found between Chinese and Dutch facial expressions, then the lower distinctiveness in Chinese expressions (if found) can be at least partially attributed to their greater intra-individual similarities when expressing different emotions.

Method

Participants and Design

In the absence of studies examining similar research questions, sample size was determined a priori based on previous cross-cultural studies of emotion production (21–25 participants per culture by Cordaro et al., 2018; 30 participants per culture by Elfenbein et al., 2007), as well as feasibility, given the time-consuming nature of manually coding facial AUs. We sought to recruit 50 participants from each culture to produce posed or spontaneous facial expressions. We employed a 2 (Culture: Chinese, Dutch) × 2 (Emotion: Anger, Disgust) × 2 (Spontaneity: Posed, Spontaneous) mixed design, with Emotion being a within-subjects factor and Culture and Spontaneity being between-subjects factors. To ensure that participants from China and the Netherlands would be similar in age and socioeconomic and educational background, we recruited student samples from the two countries.

Ninety-nine Dutch participants were recruited from a university in the Netherlands, and 97 Chinese participants were recruited from a university in China. Thirty-two participants were excluded from the analysis, either because their faces were not entirely visible or because no facial movement occurred in the specified frame for facial expression coding. The majority of the excluded participants were from the spontaneous condition ($N=27$), because participants in the spontaneous condition were not explicitly asked to show emotional expressions to the camera. This is consistent with Chovil's (1988) observation that some participants move their faces very little (a phenomenon he satirically referred to as the "problem of nonexpressive subjects"). This resulted in 49 Dutch ($M_{age}=22.94$, $SD=3.00$; 13 men) and 45 Chinese ($M_{age}=19.04$, $SD=1.33$; 23 men) participants in the posed condition, and 35 Dutch ($M_{age}=23.20$, $SD=3.05$; 11 men) and 35 Chinese ($M_{age}=19.49$, $SD=1.54$; 11 men) participants in the spontaneous condition. In return for participation, Dutch participants received 0.5 course credits, and Chinese participants received 20 CNY (approximately 4 USD).

Procedure

All instructions and materials were translated from English into Chinese and Dutch by means of the standard translation/back-translation procedure. Participants were randomly assigned to the

posed or spontaneous condition. In each condition, participants started with a neutral condition to get familiarized with the procedure; the order of anger and disgust was counterbalanced between participants. We report all measures, manipulations, and exclusions.

Posed condition. In the posed condition, participants were asked to produce facial emotional expressions such that "their friends would be able to understand easily what they feel." This instruction has previously been employed as a way to elicit voluntarily facial expressions (Elfenbein et al., 2007). Before each pose, participants were presented with an emotion label, a definition of the emotion term, and a one-sentence emotion story drawn from previous cross-cultural studies (Ekman & Cordaro, 2011; Matsumoto et al., 2005; see Supplemental Table S1 for details). This sought to ensure that participants from different cultures had a similar understanding of the target emotion terms (e.g., Cordaro et al., 2018; Sauter et al., 2010). Participants tested various expressions with a video camera. Once they were satisfied with their pose, participants rated the extent to which they had experienced each of five emotions (anger, disgust, fear, sadness, and happiness) while posing, using scales between 0 and 10 (0 = *not at all*, 10 = *extremely*). Participants also indicated how difficult they found it to pose each target emotion on a scale from 0 to 10 (0 = *very easy*, 10 = *very difficult*). Having completing the ratings after posing the first emotion, participants pressed a button that rang a bell, upon which the experimenter provided them with the next emotion label, definition, and example situation, and the procedure was repeated. The experimenter was not in the room with the participant during the posing and did not provide feedback or recommendations of any kind. The entire posing session was filmed.

After producing expressions of anger and disgust, participants were led to another room, where they looked at the video of their own expressions. They were asked to choose the frame that they thought represented the clearest expression of the instructed emotion. This approach ensures that the selected frame is an accurate representation of the participant's intended expression and avoids introducing experimenter bias into the coding procedure. Once they had selected the frame, participants rated the clarity and intensity of their expression in that frame using scales of 0 to 10 (0 = *not at all clear/intense*, 10 = *extremely clear/intense*).

Spontaneous condition. In the spontaneous condition, we used a cover story telling participants that they were going to help develop a robot that can understand human emotions. Participants were instructed to take their time to recall an event from their own life that involved angry or disgusted emotional experiences and tell this past experience in detail to the robot, Eva. In order to make the cover story more believable, we first presented participants with general information about the robot (e.g., functions and possible applications). In order to make the robot more human-like, an animation was presented to participants following the introduction, in which a virtual robot appeared on the screen, waving her hand, and talking to participants like a friend ("*Hello, I am Eva. Nice to meet you. I am glad you are willing to chat with me. I would like to know you, listen to your experience, and understand how you feel. I hope I can become one of your best friends. In a moment, I will pick a random emotion term, and you need to recall an experience relating to this emotion experience. Once you come up with something, please tell it to me, the more detailed the better.*"). Then participants proceeded to the formal testing phase, where Eva told participants to recall a particular emotional event. Similar to the posed condition, for each emotion, participants received an emotion label, a definition of the emotion term, and a one-sentence emotion story. This relived-emotion method has been shown to be an effective means of eliciting emotional expressions in previous studies (e.g., Tsai & Chentsova-Dutton, 2003). We used a robot instead of a human being because of the concern that (especially Chinese) participants might feel uncomfortable sharing negative life events with strangers and may therefore de-amplify or even mask their expressions (e.g., Matsumoto et al., 2008). Previous research

has shown that interacting with virtual humans can make people more willing to disclose negative affective information (Lucas et al., 2014).

After sharing each story, participants indicated how comfortable they felt sharing their experience with Eva on a scale from 0 to 10 (0 = *very uncomfortable*, 10 = *very comfortable*). The rest of the procedure was identical to the posed condition. Participants were fully debriefed upon completing the experiment.

Results

All anonymized raw data are available at https://osf.io/x7dbt/. Due to privacy regulations, we cannot make the video recordings publicly available, but they are available for non-commercial research purposes upon request from the corresponding author.

Preliminary Analyses on Self-Report Judgments

In both the posed and spontaneous conditions, participants' self-reported judgments of their emotional expressions and experiences were included to test whether any cultural differences found in facial muscle movements could be due to cultural differences in self-reports on expressions and experiences.

Self-reports on expressions. Using the self-report ratings, we tested whether Dutch and Chinese participants differed in their ratings of their own expression clarity, expression intensity, difficulty of posing expressions, and how comfortable they felt sharing autobiographical events with the robot. Whereas Chinese participants gave higher ratings than Dutch participants on clarity ($M_{\text{Chinese}} = 7.43$, $SD = 1.45$; $M_{\text{Dutch}} = 6.73$, $SD = 1.56$), intensity ($M_{\text{Chinese}} = 6.89$, $SD = 1.43$; $M_{\text{Dutch}} = 6.34$, $SD = 1.67$), and comfort ($M_{\text{Chinese}} = 6.13$, $SD = 2.17$; $M_{\text{Dutch}} = 5.00$, $SD = 2.08$), $ps < .030$ (see Supplemental Table S2), the groups did not differ in experienced difficulty in posing expressions ($M_{\text{Chinese}} = 4.71$, $SD = 1.86$; $M_{\text{Dutch}} = 4.99$, $SD = 1.84$), $F(1, 92) = 0.53$, $p = .467$, $\eta_p^2 = .006$. These results suggest that if the hypothesized lower distinctiveness in Chinese participants' facial expressions were to be observed, it could not be explained by their greater difficulty in posing expressions or being more uncomfortable in sharing negative autobiographical events, or by lower clarity or intensity in the judgments of their own expressions.

Self-reports on experiences. We first sought to establish whether participants experienced the emotions that they were asked to pose or share. In both posed and spontaneous conditions and in both of the cultural groups, participants rated their emotional experiences higher on the target emotion scale (e.g., anger ratings in the anger conditions) than all nontarget emotion scales (disgust, fear, sadness, and happiness ratings in the anger conditions), $ps < .001$ (see Supplemental Table S3). These results establish that participants indeed experienced the target emotions.

Second, we tested whether the induced emotional experiences were comparable across the two cultural groups, focusing on the target emotion and the nontarget emotion that has been found to be most confusable with the target one, that is, the ratings of anger versus disgust. While Chinese participants ($M = 5.53$, $SD = 1.89$) experienced more intense emotions than did Dutch participants ($M = 4.18$, $SD = 1.69$), $F(1, 160) = 23.58$, $p < .001$, $\eta_p^2 = .128$, the groups did not differ in the degree to which they experienced mixed emotions ($M_{|\text{anger-disgust}|\_\text{Chinese}} = 3.36$, $SD = 2.20$; $M_{|\text{anger-disgust}|\_\text{Dutch}} = 3.65$, $SD = 2.05$), $F(1, 160) = 0.80$, $p = .372$, $\eta_p^2 = .005$ (see Supplemental Table S4). We thus found no evidence that Chinese participants experienced more mixed emotions than Dutch participants in the current paradigm. This rules out the possibility that any observed cultural differences in distinctiveness between anger and disgust expressions could be explained by cultural differences in mixed emotional experiences.

Main Analyses on Facial AUs

The facial expressions were coded using FACS, with all facial AUs being dummy coded for absence or presence of activation for each expression. A certified FACS coder coded all the expressions, and a second certified FACS coder coded 20% of the expressions. The agreement level between the two coders was 63%, which is deemed acceptable (Ekman et al., 2002). The first coder's classifications were used for the analyses. After excluding AUs that were never active in any condition, there were a total of 40 facial AUs to consider in the analysis.

AU activity in expressions of anger and disgust. Before reporting the machine learning approach to categorize facial expressions based on the patterns of AUs, we provide an overview of the AU activity in expressions of anger and disgust across all conditions (Spontaneity × Culture) in Figure 1. As can be seen in this figure, most of the AUs were rarely active, and only a few AUs were active in a substantial proportion of participants. To distinguish meaningful AU activity from random activity, we implemented the Monte Carlo simulation method developed by Chen et al. (2018) to identify the AUs that were most frequently active in each condition.

To illustrate this method, we use the example of identifying AUs that were frequently activated for the posed angry facial expressions of Dutch participants. First, for each of the 40 AUs, we computed the proportion of expressions in which it occurred across the 49 expressions (i.e., the number of participants). For example, brow lowering (AU4) occurred in 44 of the expressions, and was therefore recorded as a 44/49 proportion of AU4 activation. Second, to decide whether this is a "highly frequent" AU, we tested if this proportion is greater than we would find if the patterns of AU activations were completely random. To test this, we performed a Monte Carlo simulation with 5,000 iterations. In each iteration, we filled a new matrix of 49 expressions × 40 AUs by randomly sampling AU activation from the original pattern of AU activity (a total of 141 AUs were active). For instance, one random iteration might produce a frequency of 7/49 for AU1, 1/49 for AU4, and so forth. Combining the resulting proportions of AU activity across all matrices (i.e., 40 proportions per iteration, and $40 \times 5{,}000 = 200{,}000$ proportions in total) yields the distribution of AU frequencies that would be observed if AU activities were completely random. This (null) distribution was then used to test whether the observed 44/49 proportion of brow lowerer (AU4) in the posed Dutch expressions of anger is significantly higher than chance, calculated as it being above the 95th percentile of the generated distribution (one-tailed $p < .05$). If so, brow lowerer (AU4) would be considered a highly frequent AU in this condition. We repeated this procedure for each AU and for each condition (Emotion × Spontaneity × Culture) separately, thereby taking into account that conditions differed in the total number of active AUs. The AUs that we identified as highly frequent are indicated with red crosses in Figure 1.

For posed expressions (the two leftmost columns), the angry and disgusted expressions of Chinese participants shared 4 frequent AUs and differed on 5 frequent AUs, while the angry and disgusted expressions of Dutch participants shared 2 frequent AUs and differed on 10 frequent AUs. For spontaneous expressions (the two rightmost columns), the angry and disgusted expressions of Chinese participants shared two frequent AUs and differed on one frequent AU, while the angry and disgusted expressions of Dutch participants shared four frequent AUs and differed on five frequent AUs. Overall, Dutch participants' expressions of anger and disgust had more unique AUs than Chinese expressions of these two emotions.

Moreover, we adapted Chen et al. (2018) approach based on Mutual Information (MI) and Monte Carlo simulation to identify AUs that were specific to facial expressions of anger or disgust depending on culture and spontaneity (see Specific AUs in Expressions of Anger and Disgust Across Cultures and Spontaneity in the Supplemental Material for details). Consistent with the pattern of results of frequent AUs, more AUs were found to be emotion-specific in the expressions produced by Dutch as compared to Chinese participants.

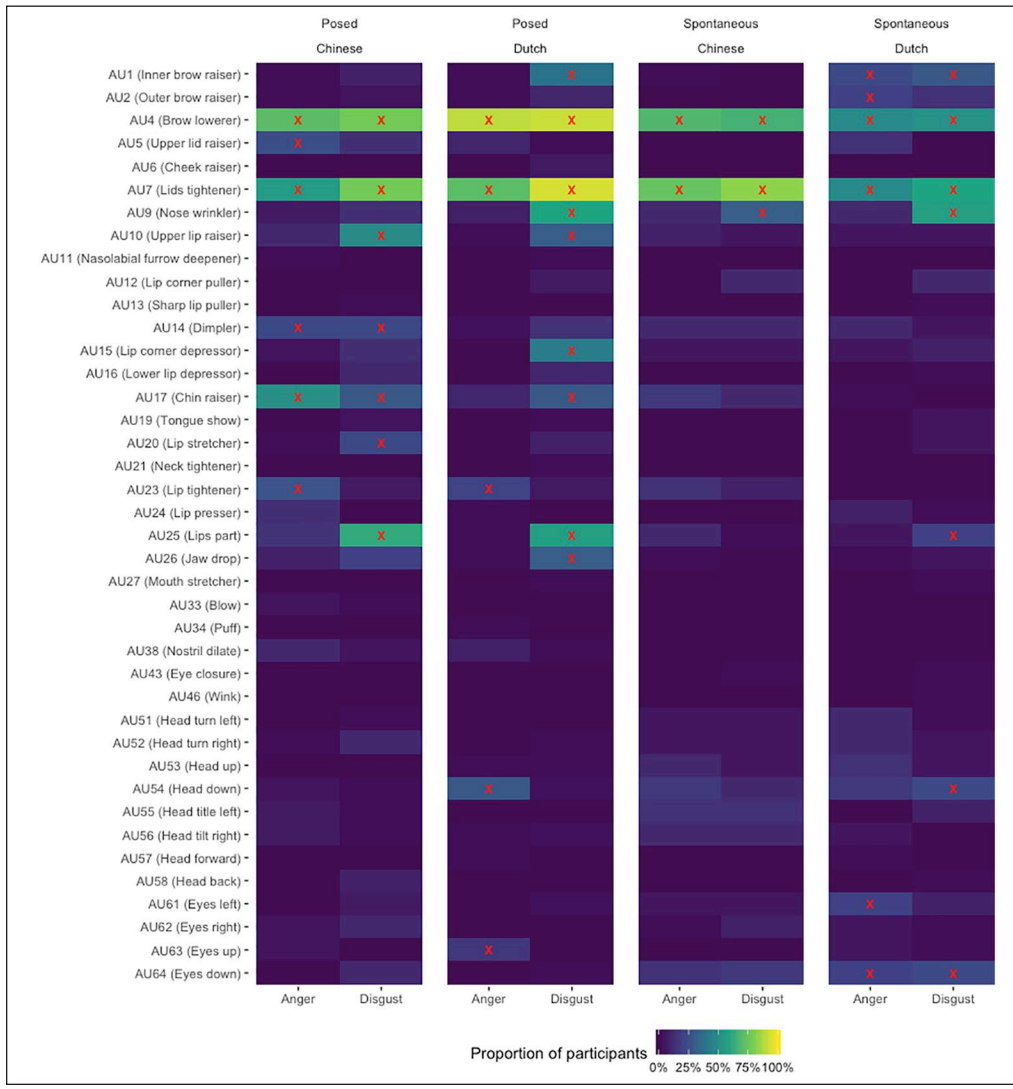

Figure 1. The activation of 40 AUs in each of the eight conditions (Emotion × Spontaneity × Culture).
Note. For each condition, the color-coded matrix shows the proportion of participants activating each AU (labels on the left). Warmer colors indicate more participants; cooler colors indicate fewer participants (see color bar at the bottom). The red crosses indicate frequent AUs for that condition, as calculated using a Monte Carlo simulation.

The Monte Carlo approach identifies the frequent AUs for the angry and disgusted expressions in a given condition, and the combined approach of Mutual Information and Monte Carlo simulation identifies the individual AUs that are specific to the angry or disgusted expressions in a given condition. These results do not, however, necessarily indicate that the combination of *frequent* or *specific* AUs in a given condition makes up the prototypical expression in that condition. For instance, one AU may only distinguish between the two expressions if it co-occurs with another AU, or a single expression may have multiple prototypes involving mutually exclusive AUs. To account for distinctiveness that is due to more complex combinations of AUs, we used a complementary machine learning approach (aka "a naïve observer") at the level of combinations of AUs (i.e., at the expression level). Our prediction would be supported by the machine

Table 1. Machine Learning Categorization Accuracy for Each of the Eight Conditions (Emotion × Spontaneity × Culture).

Culture	Spontaneity	*N*	Anger	Disgust
Chinese	Posed	45	82.2%	66.7%
	Spontaneous	35	80.0%	45.7%
Dutch	Posed	49	89.8%	95.9%
	Spontaneous	35	82.9%	74.3%

learning model being more accurate in categorizing the expressions of Dutch as compared to Chinese participants.

Machine learning-based facial expression categorization. To apply a supervised machine learning approach, we first "trained" models with a series of labeled (i.e., pre-classified) angry and disgusted expressions with their features (AU Activity, Culture, and Spontaneity); then, the models were used to categorize expressions (without being given labels) as anger or disgust. Specifically, we used logic regression with the LogicReg package in R (Kooperberg & Ruczinski, 2018) to differentiate between angry and disgusted expressions. We first fit models with varying numbers of "trees" (or predictors, ranging from 1 to 3) and varying numbers of "leaves" (or features, ranging from 2 to the maximum number, 13) per tree (Ruczinski et al., 2003). These parameters allow for anything between the simplest possible model (here: one predictor combining two AUs) and a model that combines nearly all of the observed 40 AUs in some way (here: three trees combining 13 AUs each allow for using a total of 39 AUs). To prevent overfitting the data (i.e., the model learning idiosyncratic patterns rather than true regularities), we used repeated k-fold cross-validation (20 folds, 20 repeats) to find the parameters to yield the best generalizing model (cross-validated accuracy = 77.3%; $\kappa = .55$). Applying these rules to the full data set yielded correct predictions in 78.4% of the cases. The similarity of this percentage to the cross-validated accuracy, 77.3%, indicates that the amount of overfitting is likely to be limited.

Based on the categorization accuracy obtained from the logic regression, we conducted our hypothesis test using a logistic mixed-effect model with the blme package in R (Chung et al., 2013). Accuracy was regressed on Culture, Spontaneity, and Emotion, and a random intercept for participant was included to partially control for individual differences in expressivity. The three-way interaction was not significant ($p = .553$), nor were the Emotion × Spontaneity ($p = .098$) or Culture × Spontaneity ($p = .215$) two-way interactions. The Emotion × Culture interaction ($p = .028$) and all main effects were significant ($ps < .010$). As predicted, accuracy was generally higher for the expressions of Dutch participants than those of Chinese participants ($p = .001$). This effect was further qualified by Emotion ($p = .028$), with cultural differences being greater for expressions of disgust ($OR = 0.16$, $p < .001$) than for expressions of anger ($OR = 0.65$, $p = .342$) (see in Table 1). Furthermore, accuracy was higher for posed than for spontaneous expressions ($OR = 2.36$, $p = .009$). Finally, accuracy was higher for angry than disgusted expressions ($p = .010$) although simple effects analyses showed that this was only the case among Chinese ($OR = 3.46$, $p = .001$), but not among Dutch ($OR = 0.79$, $p = .660$) participants. These results indicate that Chinese participants' disgusted expressions were more often miscategorized as anger compared to Dutch participants' disgusted expressions, suggesting that Chinese participants' disgusted expressions were less distinct from their angry expressions. These findings thus provide expression-based evidence that facial expressions of anger and disgust were more distinct in Dutch as compared to Chinese participants, and that this pattern of results did not differ between posed and spontaneous expressions.

Intra-Individual Versus Inter-Individual Variation in Emotional Expression

We have argued that differences in the distinctiveness of facial emotional expressions between members of the two cultural groups can stem from differences in intra-individual variance in the expression of different emotions and/or inter-individual variance in the expression of the same emotion. Thus, one possibility is that, compared to Dutch participants, individual Chinese participants used more similar facial movements to express anger and disgust (i.e., smaller intra-individual variation). As a result, the machine learning model (aka "a naïve observer") would have found it more difficult to distinguish between the angry and disgusted expressions of Chinese compared with Dutch participants, resulting in lower distinctiveness of Chinese expressions. Another possibility is that there were larger differences between Chinese participants in how they expressed each of the emotions (i.e., larger inter-individual variation), perhaps due to a larger array of facial prototypes for anger and disgust in the Chinese sample. As a result, the machine learning model would have found it more challenging to distinguish between expressions of anger and disgust produced by Chinese as compared to Dutch participants, whose expressions would have been more consistent.

We attempted to distinguish between these two accounts by isolating the role played by intra-individual similarities, as calculated using the Hamming distance. We calculated Hamming distance at the participant level, as a simple count of the number of AUs (out of 40) that differed between the angry and disgusted expressions produced by the same individual (i.e., the AU is active in one, but not active in the other). A 2 Culture × 2 Spontaneity ANOVA on these distances (with Type III errors) revealed a main effect of Spontaneity, $F(1, 160) = 15.90$, $p < .001$, $\eta_p^2 = .09$, and a two-way interaction between Culture and Spontaneity, $F(1, 160) = 6.13$, $p = .014$, $\eta_p^2 = .04$. Simple effects analyses showed that Chinese participants had a smaller Hamming distance than Dutch participants for spontaneous expressions ($M_{Chinese} = 2.89$, $SD = 1.79$; $M_{Dutch} = 4.71$, $SD = 2.70$), $t(160) = 3.36$, $p = .002$, but not for posed expressions ($M_{Chinese} = 4.93$, $SD = 2.26$; $M_{Dutch} = 4.98$, $SD = 2.28$), $t(160) = 0.10$, $p > .999$. This indicates that the spontaneous Chinese expressions of anger and disgust had larger intra-individual similarities of facial movements than the spontaneous Dutch expressions, whereas no cultural difference was found for the posed expressions. These results suggest that the lower distinctiveness of the spontaneous Chinese expressions is likely due at least in part to individual Chinese participants using more similar facial movements to express anger and disgust. However, the lower distinctiveness of the posed Chinese expressions cannot be attributed to greater intra-individual similarity; instead, it might reflect greater inter-individual differences, that is, larger variation in prototypes for posed facial expressions of anger and disgust in Chinese relative to Dutch culture.

Discussion

The present research examined whether Dutch versus Chinese people differ in the distinctiveness of posed and spontaneous emotional facial expressions. Using a machine learning approach, we found that Dutch participants' expressions were better categorized than Chinese participants', regardless of the spontaneity of expressions. These findings provide initial evidence that people from heterogeneous cultures express emotions in more distinct ways than people from homogeneous cultures. We further uncovered different causes of the cultural differences in posed and spontaneous expressions: While the relatively lower distinctiveness of spontaneous expressions in Chinese participants is partially explained by them using more similar facial movements to express different emotions (i.e., smaller intra-individual variation), the relatively lower distinctiveness of posed expressions in Chinese participants appears to be due to larger differences between Chinese participants in how they expressed each of the emotions (i.e., larger inter-individual variation), possibly due to them having larger variance in emotion prototypes.

The current results also demonstrate that facial expressions of anger and disgust were more distinct when they were posed as compared to spontaneous: The posed expressions of anger and disgust were better categorized than the spontaneous expressions of these two emotions. Two possibilities may account for such differences between posed and spontaneous expressions. First, participants reported more mixed feelings in the spontaneous as compared to the posed conditions (see Supplemental Tables S3 and S4 for details). It is thus possible that the relatively more mixed spontaneous facial expressions were caused by participants experiencing more mixed feelings in the spontaneous condition. Second, posed and spontaneous facial expressions might be characterized by partly different patterns of facial AUs. Previous research suggests that posed expressions might lack some facial muscle movements that do occur in spontaneous expressions or may contain extraneous facial muscle movements that do not occur in spontaneous expressions (Matsumoto et al., 2009b). Our data are consistent with this possibility: Posed and spontaneous emotional expressions shared a number of frequent AUs, yet they were also characterized by frequent AUs that did not overlap between posed and spontaneous expressions (see red crosses in Figure 1).

Notably, we did not find that culture plays different roles in the distinctiveness of posed and spontaneous facial expressions. This indicates that the distinctiveness of posed and spontaneous expressions may be shaped by culture to a similar degree, with Chinese participants producing less distinct posed as well as spontaneous expressions of anger and disgust than Dutch participants. However, the distinctiveness of posed and spontaneous expressions can be attributed to different sources. Our research suggests that the lower distinctiveness of posed expressions by Chinese participants may be related to them using more variable prototypes when posing an emotion. This is consistent with the recent findings of Cowen et al. (2021) that facial reactions to evocative videos were more variable in Japanese (homogenous culture) compared to U.S. (heterogeneous culture) participants. By contrast, the lower distinctiveness of spontaneous expressions by Chinese participants appears to be related to them using more similar facial movements to express anger and disgust. However, we could not exclude the possibility that Chinese participants might have also used a larger number of different prototypes for spontaneous anger/disgust relative to Dutch participants. Overall, these findings suggest that cultural differences in the distinctiveness of posed emotional expressions were not different from cultural differences in the distinctiveness of spontaneous emotional expressions, yet the underlying mechanisms responsible for the cultural differences observed for posed and spontaneous expressions may differ.

Consistent with previous research on the production of facial expressions across cultures (Cordaro et al., 2018; Elfenbein et al., 2007), the current results suggest an intermediate position on the universality of emotional facial expressions, such that there are both universal and culturally specific features in expressions of emotion (Cordaro et al., 2018; Elfenbein et al., 2007). For example, the posed angry expressions of Chinese and Dutch participants shared three frequent AUs (AUs 4 [brows lowerer], 7 [lids tightener], and 23 [lip tightener]) but differed on five other AUs (see Figure 1). Similarly, the posed disgusted expressions of Chinese and Dutch participants shared five frequent AUs (AUs 4 [brows lowerer], 7 [lids tightener], 10 [upper lip raiser], 17 [chin raiser], and 25 [lips part]), but differed on six other AUs (see Figure 1). Notably, all of the frequent AUs shared by cultures in the present study map onto to the AUs found in other studies on facial expressions of anger and disgust across cultures (Cordaro et al., 2018; Du et al., 2014; Jack et al., 2016).

Limitations and Future Directions

Some limitations of our study merit discussion. First, although previous research has demonstrated that people from historically heterogeneous cultures produce facial expressions of emotion that are recognized more accurately than expressions produced by people from homogeneous

cultures (Wood et al., 2016), the current findings cannot be definitely attributed to the relationship between historical heterogeneity and the distinctiveness of emotional expressions because only two cultural groups were included. We consequently cannot rule out the possibility that factors other than historical heterogeneity (e.g., individualism-collectivism, tightness-looseness, power distance) underlie the differences we observed in the distinctiveness of emotional expressions. For example, it is conceivable that individualism–collectivism, a predictor of emotion expressivity, influences the distinctiveness of emotional expressions. Matsumoto et al. (2008) found that whereas individualistic cultures tend to endorse norms allowing for relatively high emotion expressivity, collectivistic cultures tend to endorse norms encouraging relatively low emotion expressivity. Although this construct of emotion expressivity refers mainly to the intensity of emotion expressions, it may also relate to distinctiveness. Specifically, low intensity expressions (produced more commonly in collectivistic cultural contexts) might also be more challenging to identify, resulting in low distinctiveness of emotional expressions in collectivistic cultures. Future work would thus benefit from including more cultures to more closely examine the relationship between the distinctiveness of emotion production and historical heterogeneity and to better disentangle this factor from other cultural dimensions such as individualism–collectivism.

Second, due to the time-consuming nature of this study (the recruitment of cross-cultural samples that produced either posed or spontaneous emotional expressions followed by watching their own recordings to choose expressions, as well as the laborious manual coding of facial movements), we examined only anger and disgust to test the distinctiveness of emotional expressions. Besides this pair of emotional facial expressions, previous research has found that Chinese individuals are also more likely than Dutch individuals to perceive multiple emotions in facial expressions of fear and surprise (Fang et al., 2018). Given that the expression and perception of emotion are interdependent (Scherer et al., 2011), it will be worthwhile for future research to examine whether our findings also extend to expressions of fear and surprise.

Third, the gender distribution in the posed condition was not equal across the two cultural groups. However, concerns that the unequal gender distribution influenced cultural differences in the distinctiveness of emotion production are mitigated by the fact that we found a similar pattern of results for spontaneous expressions (with expressions of anger and disgust being more distinct for Dutch compared to Chinese participants), where the proportion of male/female participants was the same across the two cultures. Moreover, we included participants' gender in the generalized mixed effect model that predicted the accuracy of the labeling in the machine-learning analysis. There was no evidence for reliable main effects or interactions involving gender (four-way interaction: $p = .097$; all other terms including gender: $ps > .157$).

While the present research focused on the patterns of facial movements in static facial expressions, it is unclear whether a similar pattern of results would occur for dynamic facial expressions that we typically encounter in everyday life. In addition to facial movements, real-life expressions have other features such as the onset, peak, and offset latency (Krumhuber et al., 2013). These dynamic features may help differentiate one emotional expression from another. As such, real-life expressions of anger and disgust may well be less overlapping than our estimates, which are based on static images. We hope future research will examine this possibility. Moreover, given that nonverbal emotion communication is not limited to facial expressions of emotion, it would be worthwhile for future research to establish whether similar patterns can be found in other types of expressions, such as vocal and postural expressions of emotion.

Implications and Conclusion

The relationship between culture and distinctiveness in expressing emotions may go beyond facial expressions, extending to other channels including vocal expressions, posture, and emotional language. For instance, the relatively lower distinctiveness of expressing emotion by

Chinese participants may be reflected in them having more mixed emotion terms and/or more semantically similar emotion terms as compared to speakers of Indo-European languages like Dutch. There is some evidence supporting this notion from a cross-cultural comparison of emotion terms (Jack et al., 2016). Based on native Chinese and English speakers' ratings of semantic similarity of a core set of frequent emotion terms from Chinese and English, respectively, more semantically similar emotion terms were found in Chinese language compared to English. This was found to be especially true for negative emotions. Moreover, cultural differences in the distinctiveness of emotion expression may also shape a range of cultural products such as books, films, and advertisements. For example, actors in the most popular movies in China may express emotion in a more mixed way than those in the Netherlands. Overall, the present findings thus open the door for researchers to examine the cultural distinctiveness of emotion expression in multiple domains.

At the same time, the current findings also have direct implications for the fabrication of these cultural products. Take the example of film making. Western audiences, who are used to more distinctive and categorical emotional expressions, may be confused by Easterner actors' emotional facial expressions, which are less distinct from each other. Thus, film makers targeting international audiences may benefit from awareness of variability in the distinctiveness of emotion production. Furthermore, with the development of technology and the internet, the current findings have potential implications for the development of digital communication via technologies such as social robots. Given our findings suggesting that there are more prototypes for a single emotion in Chinese culture relative to Dutch culture, social robots used in China may need to be trained with a wider range of (especially negative) emotional facial stimuli than robots in the Netherlands.

Overall, we have shown that Dutch individuals, who are from a historically heterogeneous culture characterized by low-context communication, produce posed and spontaneous expressions of anger and disgust in more distinct ways than Chinese individuals, who are from a historically homogeneous culture characterized by high-context communication. In particular, Chinese individuals use more variable facial movements to express the same emotion for posed expressions and use more similar facial movements to express different emotions for spontaneous expressions compared to Dutch individuals. The current findings provide a novel empirical contribution to research on nonverbal emotion communication across cultures, with implications for social interactions and cultural products.

Author Contributions

Xia Fang, Disa A. Sauter, and Gerben A. Van Kleef developed the study concept and design. Xia Fang collected data. Xia Fang and Marc W. Heerdink performed the data analysis and interpretation under the supervision of Disa A. Sauter and Gerben A. Van Kleef. Xia Fang drafted the manuscript, and Marc W. Heerdink, Disa A. Sauter, and Gerben A. Van Kleef provided critical revisions. All authors approved the final version of the manuscript for submission.

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Supplemental Material

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