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BRIEF REPORT

Categorical Perception of Emotional Facial Expressions Does Not Require Lexical Categories

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Does our perception of others' emotional signals depend on the language we speak or is our perception the same regardless of language and culture? It is well established that human emotional facial expressions are perceived categorically by viewers, but whether this is driven by perceptual or linguistic mechanisms is debated. We report an investigation into the perception of emotional facial expressions, comparing German speakers to native speakers of Yucatec Maya, a language with no lexical labels that distinguish disgust from anger. In a free naming task, speakers of German, but not Yucatec Maya, made lexical distinctions between disgust and anger. However, in a delayed match-to-sample task, both groups perceived emotional facial expressions of these and other emotions categorically. The magnitude of this effect was equivalent across the language groups, as well as across emotion continua with and without lexical distinctions. Our results show that the perception of affective signals is not driven by lexical labels, instead lending support to accounts of emotions as a set of biologically evolved mechanisms.

Keywords: emotion, facial expressions, categorical perception, language

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How do we infer from others' emotional signals how they feel? Some theorists argue that communication of emotions like anger, disgust, and sadness, are the result of language-independent, biologically driven affect programs (e.g., Ekman, 1992), while others claim that emotional communication is based on learned distinctions acquired via language (e.g., Roberson & Davidoff, 2000). In this study, a cross-cultural comparison is presented that tests the predictions of these two accounts against each other, examining whether lexical categories are necessary for categorical distinctions between emotional facial expressions.

According to the influential account proposed by Ekman (1992), certain human emotions are evolved, adaptive functions that mobilize body and brain to deal with issues that are crucial for survival, such as avoiding threat or noxious substances. Ekman and others have argued that these "basic" emotions—happiness, disgust, sadness, anger, surprise, and fear—can be found in all human cultures, with the same distinct physiological profiles and facial expressions, and that the ways in which we signal and perceive others' emotional signals are largely determined by hardwired mechanisms. According to this view, these emotions have each evolved to serve different functions and thus constitute separate psychological mechanisms, and signals should consequently be perceived as distinct categories rather than blends.

Empirical support for the view that emotional signals are perceived as categorically distinct has come from perceptual tasks of morphed continua of facial expressions of emotions. In an early study, Etcoff and Magee (1992) compared discrimination of pairs of morphed drawings of prototypical emotional facial expressions. Viewers perceived the expressions as either one emotion or the other, rather than as blends, despite the stimuli being continuous. This phenomenon, known as categorical perception (CP), has also been found for other types of stimuli, including colors and phonemes. In these perceptual domains, physical continua (e.g., wavelength or voice onset time) are not perceptually linear (see Calder, Young, Perrett, Etcoff, & Rowland, 1996). For emotional facial expressions, Etcoff and Magee argued that if perceivers are trying

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to detect states that can motivate the sender's behavior in a predictable way, a blend of emotions would be difficult to interpret meaningfully. Rather, relying on the dominant emotion in the signal would be more likely to yield an accurate prediction about the sender's likely behavior. Etcoff and Magee argued that their result of CP of emotional facial expressions supported Ekman's view that emotions and emotional signals are fundamentally categorical. Calder, Young and colleagues extended Etcoff and Magee's finding by ruling out alternative explanations for the CP result, such as anchor effects, short-term memory function, and dimensional features (Calder et al., 1996; Young et al., 1997).

However, other theorists have questioned this view, and have emphasized the role of language and culture in the human perception of emotional signals (Barrett, Lindquist, & Gendron, 2007; McCullough & Emmory, 2009). Specifically, CP of emotional facial expressions has been suggested to arise through verbal coding rather than through emotion-specific evolutionary mechanisms. A recent study by Fugate, Gouzoules, and Feldman Barrett (2010) found that learning to associate labels with chimpanzee facial configurations could induce CP. This is consistent with findings by Roberson and Davidoff (2000), who showed that verbal, but not nonverbal interference, disrupted CP in human subjects. Roberson and Davidoff argued that this showed that CP is the result of verbal coding, rather than lower-level perceptual processing. Specifically, categorical perception has been suggested to occur via the activation of a prototype of a semantic category at encoding (Huttenlocher, Hedges, & Vevea, 2000).

The objective of the current study was to provide an empirical test of the mechanism underlying CP of facial expressions of emotions, contrasting the predictions derived from accounts proposing a language or a perceptual basis for this phenomenon. In order to examine this question, we investigated whether CP of emotional facial expressions would occur in speakers of a language that has only one lexical category for the two basic emotions anger and disgust. Yucatec Maya is a language spoken by approximately 800,000 indigenous people in the Yucatán peninsula in Mexico and in Northern Belize. Ethnographic work has suggested that Yucatec Maya does not have a word for disgust (Le Guen & Pool Balam, 2008). Furthermore, standard dictionary entries for Spanish terms equivalent to the English term "disgust" (e.g., *asco*) yield Yucatec Mayan terms (*p'eek, p'uha'an, ts'íik*) that when back-translated have meanings close to "anger" (e.g., the Spanish term *aborrecer*; Bastarrachea Manzano & Canto Rosado, 2003; Bricker, Po'ot Yah, & Dzul de Po'ot, 1998).

If CP is caused by the activation of the learned labels of the stimulus categories (Roberson, Damjanovic, & Pilling, 2007), CP should not occur on the anger-disgust continuum in Yucatec Maya speakers, since the lexical category for disgust is conflated with that of anger. In contrast, if CP of emotional facial expressions reflects biologically relevant boundaries between distinct categories regardless of lexical labels (Dailey et al., 2002; Ekman, 1992; Etcoff & Magee, 1992), CP should be observed to the same extent regardless of viewers' lexical distinctions.

Our study aimed to examine whether the absence of learned lexical categories would affect the CP of emotional facial expressions, by testing whether native speakers of Yucatec Maya would show CP of emotional facial expressions of the continuum between disgust and anger, and if they did, whether this effect would be of the same magnitude as that seen in another language group that does make the lexical distinction (German). Two further continua were included for comparison. The continua between anger and sadness and disgust and sadness were used to establish the existence and magnitude of CP of emotional facial expressions in Yucatec Maya speakers on continua where each end-point of the continuum has a label.

Method

Emotion Term Elicitation

In order to establish the Yucatec Maya and German lexical categories for the facial expressions in the main task, 15 Yucatec participants (8 female, mean age 31.7 years) and 12 German participants (7 female, mean age 32.8 years) took part in a free naming task, as part of a larger study (Levinson, Senft, & Majid, 2007). Participants were shown one male and one female facial expression of anger, disgust, and sadness from the Ekman and Friesen (1976) set and asked to freely describe how they thought that the person in each photograph was feeling (see online Supplementary Table 1 for the most frequent responses). While the German participants used different terms to describe the angry and the disgusted face, the Yucatec participants made no distinction in their free naming of these two expressions. However, naming of the sad facial expressions was differentiated from that of disgust and anger in both language groups.

In addition, the German participants and 12 Yucatec participants (a subset of those who had performed the face naming task; 7 female, mean age 33.4 years) performed a second task, where they were asked to name the emotion felt by a person in a series of emotion vignettes, involving prototypical situations eliciting anger, disgust, and sadness (see online Supplementary Table 2 for vignettes). These data were consistent with the result for the emotional faces, with the Yucatec participants using the same terms for the anger and disgust stories, while the German participants used different labels to describe the two scenarios (see online Supplementary Table 1). Both groups differentiated the sad scenario from the other emotions. These results confirm that Yucatec Maya does not have a lexical category for "disgust" that differentiates it from "anger," while German does. Furthermore, in both Yucatec Maya and German the lexical category for "sadness" is distinct from that of both "disgust" and "anger."

Yucatec Maya contains other terms that describe aspect of facial expressions (e.g., wrinkled nose, open mouth), which can also imply mental states (Le Guen & Pool Balam, 2008). Terms of this kind do not describe affective states and were not used in the free naming descriptions of the emotional expressions or stories in this study, consistent with studies showing that emotional facial expressions are typically processed configurally rather than in terms of individual features (Calder, Young, Keane, & Dean, 2000). But would these terms would be used to describe these facial expressions if the affective contents of the expressions was not emphasized? The Yucatec participants had, as part of an earlier study (Levinson, Senft, & Majid, 2007), been asked to name an additional set of male emotional facial expressions from the Ekman and Friesen (1976) set, with the emotion-neutral question "How does the face look?" The results from this elicitation paralleled the findings from the other naming tasks, with Yucatec participants describing the faces as "angry" (angry and disgusted faces), and

"sad" (sad face). Only one response involved a physical term that could imply a mental state, while the most common descriptions for all three expressions were emotion terms, again confirming the lexical overlap between disgust and anger in Yucatec Maya.

Categorical Perception Task

Participants

Twenty-three native Yucatec Maya speakers (12 female, mean age 31.2 years) and 22 native German speakers (15 female, mean age 22.8 years) took part in the experiment. Two years before performing the CP task, five male and four female Yucatec participants had taken part in the facial expression elicitation task, and three male and four female Yucatec participants had also performed the elicitation task with the emotion vignettes.

Materials and Methods

The facial expression images were taken from the Facial Expressions of Emotion: Stimuli and Tests (FEEST; Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002). This stimulus set consists of black-and-white photographs of male and female Caucasian faces, showing a range of typical emotional facial expressions. The three emotions sadness, disgust and anger were included in the CP task, all posed by a single male individual (JJ). These images are all well-recognized expressions of negative emotions across cultures (Ekman, Sorenson, & Friesen, 1969; Elfenbein & Ambady, 2002). The FEEST contains images that are morphed in equal steps on continua between emotions. All continua between the three emotions were used: disgusted—sad, sad—angry, and angry—disgusted. Pairs of faces, two morphed steps apart (20%), were constructed (see Figure 1). The two members of a pair contained either predominantly the same expression (e.g., 80% disgusted/20% sad and 60% disgusted/40% sad) or predominantly different categories (e.g., 60% disgusted/40% sad and 40% disgusted/60% sad), with the two stimuli always 20% apart (see online Supplementary Table 3 for the trial types used). All stimuli were displayed on a Toughbook computer, running a purpose-written program in E-prime.

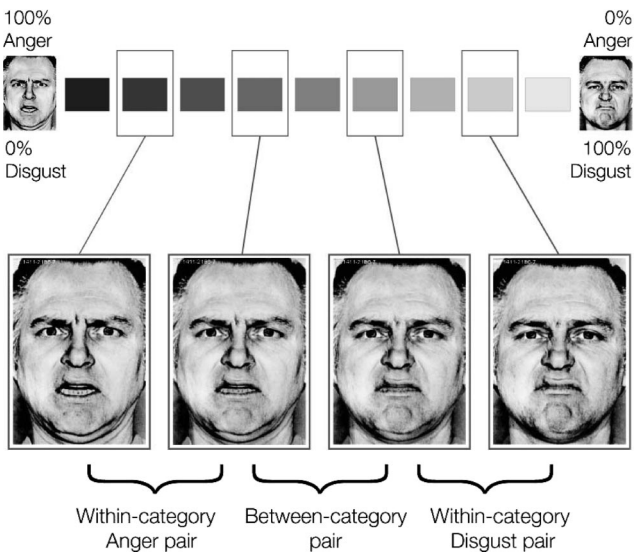

Figure 1. Range of morphs on the Anger-Disgust continuum and examples of trial types.

Procedure

Participants carried out six practice trials with feedback on accuracy before the start of the experimental trials, to ensure that they understood the task and could perform it without using language. Unmorphed prototype expressions were used in the practice trials. Apart from the stimuli and the use of feedback, the practice trials were identical to the main task. All participants were able to perform the practice task successfully without using language and carried on to the main task.

On each trial, a target stimulus was presented in the center of the screen for 1,000 ms, followed by two stimuli. One of these was the target face, identical to the stimulus just displayed. The other stimulus was a distractor (see online Supplemental Table 2), differing from the target only in expression. Participants were asked to point to the face that they thought they had just seen and the experimenter entered their response into the computer with a key press. No feedback was given, and the intertrial interval was self-paced. The task consisted of 72 trials in total, with 8 repetitions of each pair. Trial order was randomized, and the position of the target face within the test pair was pseudorandomized so that it appeared in each position (left or right) on half the trials. Instructions emphasized accuracy.

Spanish Term Knowledge

Since many Yucatec Maya speakers know some Spanish, we tested whether the Yucatec participants were familiar with any Spanish terms for disgust, in order to ensure that they did not have access to a distinct lexical category for disgust borrowed from Spanish. Following the testing session, all participants were asked, in Yucatec Maya, to give a definition of the Spanish terms for 'disgust,' *asco* and *repugnacia* (Galimberti Jarman & Russell, 2001). Approximately half of the Yucatec participants reported not being familiar with the words, and most of the remaining participants defined them as the feeling following interpersonal conflicts (i.e., "anger"). None of the participants gave definitions suggesting they understood the meaning of the Spanish terms as "disgust," demonstrating that none of the Yucatec participants had access to distinct lexical categories for disgust and anger from their knowledge of Spanish.

Results

Participants in both groups perceived the facial expressions categorically, with faces straddling a category midpoint being distinguished more accurately than faces within a category (see Figure 2). A repeated measures ANOVA was performed using the arcsine transformed proportions of correct responses for between- and within-category trials on each continuum. Language group was included as a between-subjects factor, and emotion continuum and category crossing were within-subject factors. The analysis revealed a significant main effect of category crossing, $F_{(1,43)} = 31.00$, $p < .0001$; $\eta_p^2 = .42$, reflecting the better performance with between-category trials

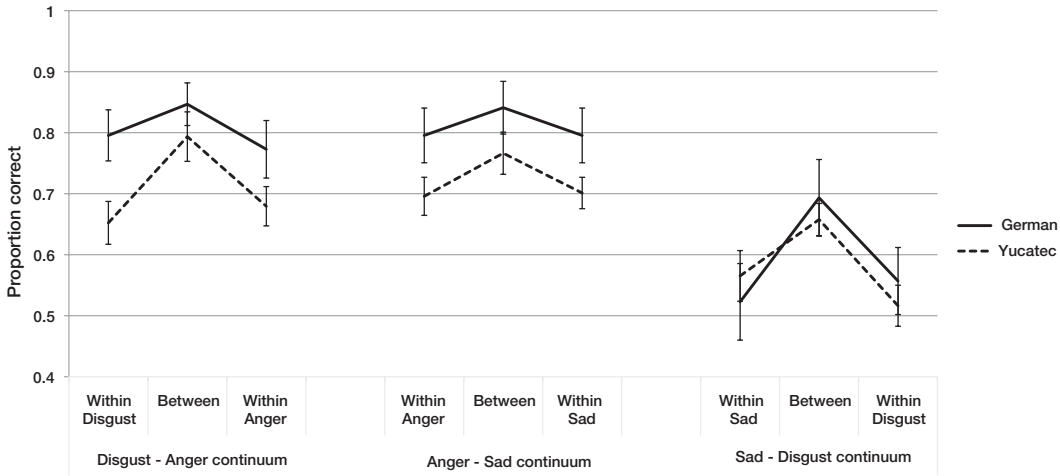

Figure 2. Proportions of correct responses for between-category and within-category stimulus pairs on each continuum for German (solid line) and Yucatec (dashed line) participants. Note: Chance is 0.5. Error bars denote standard errors.

across the two groups (raw proportion mean for between-category trials: 0.77, and for within-category trials: .67).[1] No interaction of category crossing with language group or continuum was found, suggesting that the CP effect was consistent across the groups and continua. A main effect of continuum was found, $F_{(2,86)} = 46.76$, $p < .0001$ $\eta_p^2 = .52$, due to the better performance with pairs on the disgust-anger (raw proportional mean .77) and sadness-anger continua (raw proportional mean .77), compared to the disgust-sadness continuum (mean .61) across both groups. There was also a main effect of group, $F_{(1,43)} = 5.95$, $p < .05$ $\eta_p^2 = .12$, with the German participants' overall performance being somewhat higher (raw proportional mean .75 for the German group, and .69 for the Yucatec), likely due to the German sample having more experience with computers and standardized testing.

To provide a more stringent test of whether each group showed CP on each continuum, *t* tests were performed to compare performance on within- and between-category trials on each continuum in each language group separately. Both groups showed CP for all three continua (Yucatec: Disgust-Anger: $t_{(22)} = 3.17$, $p < .01$, Disgust-Sadness: $t_{(22)} = 3.30$, $p < .01$, Sadness-Anger $t_{(22)} = 2.26$, $p < .05$; German: Disgust-Anger: $t_{(21)} = 2.15$, $p < .05$, Disgust-Sadness: $t_{(21)} = 2.70$, $p < .05$, Sadness-Anger $t_{(21)} = 2.03$, $p = .055$).

Discussion

The results of this study show that facial expressions of emotions are perceived categorically regardless of whether the viewer has lexical categories that distinguish between the perceptual categories. In a delayed match-to-sample task, speakers of both German and Yucatec Maya performed more accurately when faces straddled a category boundary compared to trials in which the faces were from the same category. This pattern was found across all continua, despite Yucatec Maya speakers not lexically differentiating between two of the emotion categories when asked to name the emotional expressions in a separate task.

Our results are at odds with the recent finding that CP is induced by learning to associate configurations with verbal labels (Fugate et al., 2010). In their study, Fugate examined whether learning label associations would result in CP of chimpanzee facial configurations. They found that the group who had learned labels showed CP on four of six continua, whereas the control group only showed CP on two continua, a finding that the authors claimed supported the view that linguistic categories determine our perception of emotional signals. However, neither group showed a statistically significant difference between their ability overall to discriminate between-category pairs compared with within—category pairs, meaning that Fugate et al.'s findings could be taken to show that human viewers do not show CP for the chimpanzee facial configurations used in their study. Fugate et al. further argue that their findings are inconsistent with the "structural account," which holds that the facial movements of facial expressions allow the viewer to infer the sender's emotional state (e.g., Ekman, 1992). According to Fugate et al., the structural account should predict that human viewers show CP for chimpanzee facial configurations, since there is extensive muscular overlap between human and chimpanzee faces. However, it does not follow from the "structural" argument that CP should occur for any facial movements, including configurations typical of other species.

Our results instead lend support to accounts of emotions as a set of discrete, evolved mechanisms (Ekman, 1992). In line with this view, Young, Rowland, Calder, Etcoff, Seth, and Perrett (1997) have proposed that the perception of emotional facial expressions is based on

[1] Some authors have found that participants perform badly on within-category trials only when the target is closer to the category boundary than the distractor (Hanley & Roberson, 2011; Roberson, Damjanovic, & Pilling, 2007). We conducted an additional analysis to test for an effect of within-category trial type, comparing within-category trials where the target was closer to the category boundary to within-category trials where the distractor was closer to the category boundary. The analysis found no support for an overall difference between the two types of within-category trials ($p > .2$). We also found no three-way interaction between within-category trial-type, group, and continuum ($p > .8$), which would be expected if distinct verbal labels are necessary to activate category representations.

a system predisposed to making rapid classifications of prototypical stimuli. Specifically, they suggested that classifications are not based on labeling the categories, but rather a consequence of bottom-up learning of particular facial constellations. This proposed mechanism may explain how the Maya participants in the current study have formed distinct perceptual categories for disgust and anger.

Computational models of emotion perception have also lent support to language-independent, bottom-up accounts of emotional face processing (Dailey, Cottrell, Padgett, & Adolphs, 2002). Dailey et al. trained a neural network model to classify facial expressions, and found that the model showed CP, just like human participants. Since the neural network had access only to perceptual information, but no lexical categories, this suggested that perceptual, rather than linguistic, factors could account for human CP effects. Dailey et al. argued that their results suggested that "evolution did not randomly associate facial expressions with emotional states, but that the expression-to-emotion mapping evolved in tandem with the need to communicate emotional states effectively" (p. 1169). This is consistent with a wealth of data showing that some emotional states, including the three used in the current study, can be reliably inferred from facial expressions, regardless of the sender and receiver's cultural background (e.g., Ekman et al., 1969; Elfenbein & Ambady, 2002) and that they rely on partially separate neurobiological systems (e.g., Lawrence, Calder, McGowan, & Grasby, 2002; Phan, Wager, Taylor, & Liberzon, 2002; Phillips, Young, Senior, Brammer, Andrew, Calder et al., 1997; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998). However, previous cross-cultural studies have typically compared groups of participants who had different labels for each facial expression. In contrast, the Yucatec participants in our study lacked a lexical distinction between disgust and anger. Nevertheless, their performance demonstrates that they were able to distinguish these facial expressions.

In sum, our results show that emotional facial expressions are perceived categorically regardless of viewers' lexical categories. This finding suggests that the perception of affective signals is not driven by lexical labels, instead lending support to accounts of emotions as a set of biologically evolved mechanisms. These results also question the assumption that languages necessarily reflect and affect emotion perception.

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