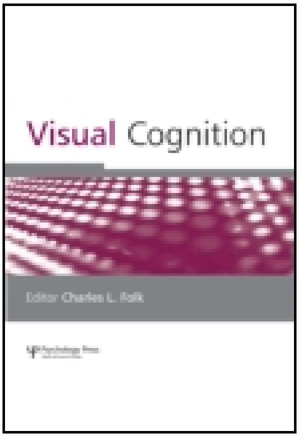

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Culture and facial expressions of emotion

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Culture and facial expressions of emotion

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With over a century of theoretical developments and empirical investigation in broad fields (e.g., anthropology, psychology, evolutionary biology), the universality of facial expressions of emotion remains a central debate in psychology. How near or far, then, is this debate from being resolved? Here, I will address this question by highlighting and synthesizing the significant advances in the field that have elevated knowledge of facial expression recognition across cultures. Specifically, I will discuss the impact of early major theoretical and empirical contributions in parallel fields and their later integration in modern research. With illustrative examples, I will show that the debate on the universality of facial expressions has arrived at a new juncture and faces a new generation of exciting questions.

Keywords: Culture; emotion; Facial expressions; Categorical perception; Modelling; Top-down processing.

All social interactions critically rely on the mutual understanding of emotions, achieved primarily by exchanging a set of potent signals—facial expressions. Serving such a fundamental function in human society, facial expressions have been the source of fascination and empirical investigation amongst philosophers, anthropologists, psychologists, and biologists for over a century (Lewis, Haviland-Jones, & Barrett, 2010). With rapid globalization and cultural integration within an emerging digital economy, cross-cultural communication is now fast becoming essential in highly connected modern society (Hermeking, 2005; Krishna, Sahay, & Walsham, 2004; Marcus & Gould, 2000; Walls, 1993). In meeting these evolving communication needs, understanding the complexities of emotion communication has recently expanded to traditionally distinct disciplines such as engineering (Thai, Nguyen, & Hai, 2011; Valstar, Jiang, Mehu,

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Pantic, & Scherer, 2011), robotics including companion robots (Khooshabeh, Gratch, Haung, & Tao, 2010; Koda, Ruttkay, Nakagawa, & Tabuchi, 2010; Rehm, Nakano, Koda, & Winschiers-Theophilus, 2012; Trovato, Kishi, Endo, Hashimoto, & Takanishi, 2012; Wang, Rau, Evers, Robinson, & Hinds, 2010), and computer science (Fu, Yang, & Kuai, 2012; Tinwell, Grimshaw, Nabi, & Williams, 2011; Vinciarelli, Pantic, & Bourlard, 2009). As a result, modern approaches to examining emotion communication are characterized by increasingly sophisticated methods that combine knowledge and techniques imported from complementary fields (e.g., Chiao & Blizinsky, 2010; Jack, Garrod, Yu, Caldara, & Schyns, 2012; Martinez & Du, 2012; Susskind et al., 2008).

Yet, a central debate remains—are facial expressions universal? That is, do humans across all cultures communicate emotions using the same set of facial expression signals? Aside from the fundamental importance of the debate, understanding emotion communication with and between cultures is timely in the digital economy. For example, should companion robots and digital avatars be designed to display a set of facial expressions that are universally recognized, or should they be tailored to express culture-specific emotions? Given that such questions require diverse knowledge from human communication and social interaction, information processing (e.g., pattern recognition) and learning, psychology as a discipline, although young, is well equipped to address these issues. Here, I will present the modern knowledge arising from this long debate, highlighting the significant advances achieved over its course and the challenges that lie ahead.

With a long and varied history, it is first useful to understand the origins of the universality debate and how subsequent scientific thinking shaped the future directions of facial expression research today (see also Russell, 1994, for an excellent summary of the historical development of the field).

GOD VS. BIOLOGY VS. CULTURE—POLAR BEGINNINGS

Although primarily concerned with documenting the anatomical mechanisms of facial expressions, the noted anatomist Sir Charles Bell (1844; see also Henle, 1868) and neurologist Guillaume Duchenne (1862/1990) proposed that God had bestowed man with facial muscles solely for the purposes of emotion communication. Although quite inadvertently, their views on the origins of facial expressions stirred doubt in the mind of one the most influential scientists of all time—Charles Darwin. Unconvinced that facial expressions were simply arbitrary muscular patterns given by God for the sole purpose of emotion communication, Darwin aimed to reveal the true origins of facial expressions in his seminal works, *The Expression of the Emotions in Man and Animals* (Darwin, 1872/1999). Here, he directly asked for the first time "why?" That is, why do facial expressions take on their distinctive form? For example, why is the emotion disgust typically accompanied by a raised top lip, wrinkled nose, and narrowing of the eyes (see Figure 1A), whereas fear is associated with wide opened eyes and flared nostrils (see Figure 1B)? Why should these apparently arbitrary facial patterns accompany different internal emotions?

Darwin's legacy—the biological origins of facial expressions of emotion

In observing that primates of human ancestry possessed facial muscles and facial expressions similar to those of humans, Darwin surmised that facial expressions originally developed to perform some adaptive function when humans "existed in a much lower and animal-like condition" (Darwin, 1872/1999, p. 11). Consider the facial expression of disgust (see Figure 1A), characterized by a raised top lip, wrinkled nose, narrowing of the eyes, and lowered eyebrows. These specific patterns of facial muscle contraction could facilitate adaptive action by protecting against the entry of pathogens and providing an effective strategy for rejecting noxious contaminants. Given the highly adaptive role of facial expressions and their ability to increase the chances of survival (e.g., by rejecting noxious contaminants), traits facilitating the production and recognition of facial expressions would be passed on to the next generation by natural

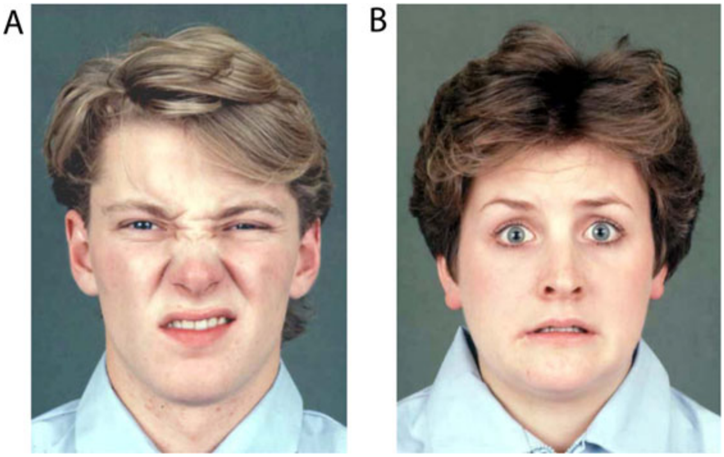

Figure 1. Examples of the facial expressions of disgust and fear. (A) Disgust. An example of the facial expression typically associated with the internal emotion disgust. Note the characteristic raised top lip, wrinkled nose and narrowing of the eyes. (B) Fear. An example of the facial expression typically associated with the internal emotion fear. Note the characteristic wide opened eyes and flared nostrils. Both images are selected from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE) stimulus set (Matsumoto & Ekman, 1988). To view this figure in colour, please see the online issue of the Journal.

selection. Thus, Darwin argued that facial expressions are innate and evolved human behaviours, which have retained the original configuration of muscle contractions that originally served to regulate sensory experience.

In an elegant study, Susskind et al. (2008) provide data that directly supports this claim. Combining convergent methods of statistical face modelling, psychophysics, temporal fixation analyses, physiological measures and MRI, Susskind and colleagues show that facial expressions of fear and disgust modulate sensory exposure by virtue of their specific patterns of facial movements. Specifically, facial expressions of fear increase nasal inspiration and air velocity by flaring the nostrils, and increase visual field information by widening the eyes and increasing fixation sampling rate. In contrast, disgust confers the opposite advantage by blocking the nasal passage and diminishing visual stimulation (see Jack, Garrod, & Schyns, 2013, who also show early eye widening in surprise and early nose wrinkling in anger; Susskind et al., 2008). Using similarly rigorous methods, Chapman, Kim, Susskind, and Anderson (2009) further demonstrated a direct biological link in facial expressions of disgust by identifying a common oral-nasal rejection response in moral, visceral, and gustatory disgust facial responses (see also Rozin, Lowery, & Ebert, 1994, for physical similarities in facial expressions of moral and visceral disgust). Finally, Lee, Susskind, and Anderson (2013) recently showed that the biologically adaptive eye widening also confers an advantage to the receiver, supporting evolutionary accounts of sensory and social functions. Together, these data support the Darwinian hypothesis that some facial expressions originally served an adaptive biological function before evolving as social signals (see Shariff & Tracy, 2011, for a summary of theoretical and empirical support for the biological origins of facial expressions).

With similar observations in the facial behaviours of primitive primates, other mammals (e.g., Vick, Waller, Parr, Smith Pasqualini, & Bard, 2007), and neonates and infants (Camras et al., 1998; Hiatt, Campos, & Emde, 1979; Rozin & Fallon, 1987), these intuitive assertions predicted widely shared theories across evolutionary biology (e.g., Andrew, 1963) and social psychology (e.g., Curtis & Biran, 2001; Rozin et al., 1994). Darwin's theory on the biological and evolutionary origins of facial expressions rapidly gained popularity, with notions of universality becoming a widespread working assumption. As a result, little or no cross-cultural research in facial expression recognition or production was conducted or even deemed necessary. For example, some of the first facial expression recognition studies (e.g., Buzby, 1924; Feleky, 1914; Goodenough & Tinker, 1931; Munn, 1940) did not consider cultural (or racial factors, i.e., the Other Race Effect [ORE]; see Feingold, 1914) as a potential source of variation. Thus, facial expressions were largely considered to be the biologically hard-wired "universal language of emotion".

Anthropological observations from across the world

Yet, with increasing knowledge of human behaviour across cultures, notions of universality and the idea of "basic human nature" became a source of fervent debate. From Alaska to Zanzibar, anthropological observations detailed surprising cultural differences in behaviours widely assumed to be instinctual, biological, and universal (e.g., gestures indicating "yes" and "no", greeting customs; see Holt, 1931). Cogent examples include the masking of negative emotions with smiles and laughter in Japan (Hearn, 1894) and Africa (Gorer, 1935), or neutral facial expressions amongst the Utku (Utkuhikhalingmiut) Eskimos (Briggs, 1970). In contrast, the Kiowa Tribe of Oklahoma encourage the enthusiastic outward expression of emotion during specific events, even in the absence of an internal emotion (see observations of Mary Buffalo in Labarre, 1947, p. 55). Such observations mirror those of the explorer and historian John Turnbull who reported that Tahitians, after a long separation, greeted each other by "taking a shark's tooth, [and] strik[ing] it into their head and temples with great violence, so as to produce a copious bleeding" (1805, pp. 301–302). Left with only incomprehension as to the origins or symbolic relevance of this ritual, Turnbull concluded that such behaviour was intended to "express the excess of their joy" (see also Darwin, 1872/1999, for detailed descriptions of culture-specific facial expressions).

With much observational evidence of cultural specificity, anthropologists largely rejected notions of universality, instead proposing that facial expressions are socially learned, not instinctual behaviours (e.g., Klineberg, 1940; Labarre, 1947; Mead, 1975). With irreconcilable accounts across the social sciences, opinion remained largely divided, sparking a controversial debate that continues to this day.

EMOTION COMMUNICATION—A SYSTEM OF SIGNALLING AND DECODING FACIAL EXPRESSION SIGNALS

Whether biologically innate or culturally determined, it is important at this stage to step back from this specific debate and examine facial expressions in a broader context. At an abstract level (e.g., Shannon, 2001), facial expressions and their recognition are part of a dynamic communicative system of signalling and decoding. Thus, to understand the complexities of emotion communication, it is important to first define the system of communication and its relevant components. Here, I present a formulation of emotion communication, as illustrated in Figure 2. As discussed in biological signalling (e.g., Scott-Phillips, 2008) and engineering (e.g., Shannon, 2001), communication is the act of successfully transmitting a message between two agents (here, two humans), with the purpose of benefiting both the sender and receiver (but see also

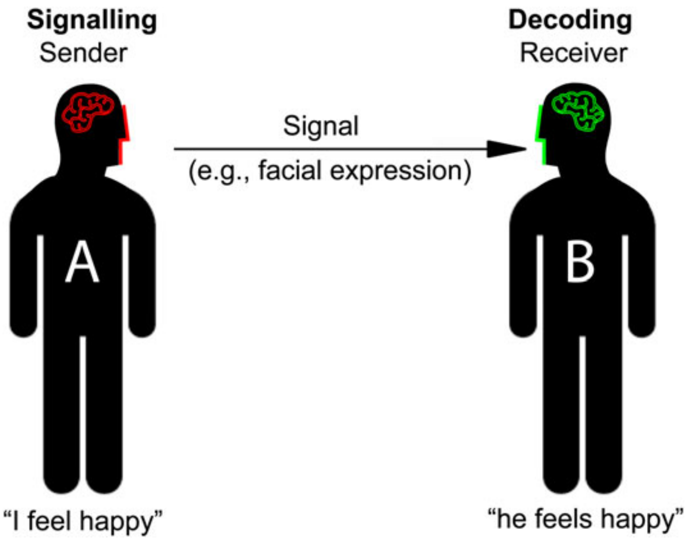

Figure 2. Signalling and decoding framework. Whether innate or learned, facial expressions of emotion form part of a dynamical system of signalling and decoding. Signalling. The sender (A) encodes a message (e.g., "I feel happy") as a signal (e.g., facial expression, body movement, vocalization) and transmits the signal across a communication channel to the receiver (B, e.g., visual or auditory system). Decoding. To decode the signal, the receiver (B) extracts the task-relevant (i.e., diagnostic) information and performs an interpretation (i.e., categorical perception) based on top-down information (i.e., prior knowledge), thereby accurately reconstructing the message (e.g., "he feels happy"). To view this figure in colour, please see the online issue of the Journal.

Dawkins & Krebs, 1978, on cheating). As shown in Figure 2, the sender (A) encodes the message ("I feel happy") as a signal (e.g., facial expression, body movement, vocalization) and transmits it across a communication channel (e.g., light, sound) to the receiver (B, e.g., the visual or auditory system). To decode the signal, the receiver (B) extracts the task-relevant (i.e., diagnostic) information and performs an interpretation (i.e., categorical perception) based on top-down information (i.e., prior knowledge), thereby accurately reconstructing the message (e.g., "he feels happy").

As already illustrated, communication involves the *signalling* and *decoding* of information (e.g., facial expression signals, body gestures, vocalizations, and their interactions) with the purpose of accurately sending a message to a receiver. As a result, all theoretical developments and empirical investigations of facial expressions of emotion have focused (explicitly or implicitly) on either their signalling or decoding. Thus, to provide a cohesive understanding of facial expressions as a system of communication, I will highlight the major theoretical and empirical advances in the signalling and decoding of facial expressions across cultures. Given the plethora of recognition studies, I will start with decoding.

DECODING FACIAL EXPRESSION SIGNALS

As described earlier, decoding involves the receiver extracting task-relevant information from the signal (i.e., facial expression) and performing an interpretation (e.g., emotion categorization) based on top-down information (i.e., prior knowledge)—otherwise known as recognition. Here, I will summarize and review the main empirical advances in understanding the recognition of facial expressions between cultures.

A landslide victory—the universal recognition of facial expressions

As an evolutionary biologist, Darwin first noted the intimate link between signalling and decoding, stating "[one of the] leading principles, which have determined the chief movements of expression [is the] recognition of expression" (1872/1999, p. 208). With his scientific texts featuring the first printed photographs—a great technical feat for the time—he first introduced recognition as an approach to study the universality of facial expressions, conducting several "judgement studies" in England (see Ekman, 1999). However, recognition would not be used extensively in the universality debate until almost a century later.

With increasing debate on whether facial expressions are innate (and therefore universal) or socially learned (Bruner & Tagiuri, 1954), empirical research dedicated to unravelling the nature/nurture debate ensued. Most notably, Ekman, Sorensen, and Friesen (1969) conducted one of the first cross-cultural recognition studies using a "standard set of facial photographs" depicting "pure" (i.e., free from culturally learned display rules)[1] facial expressions of six primary emotions—happy, surprise, fear, disgust-contempt, anger, and sad (Tomkins, 1962, 1963). Using an alternative forced choice (AFC) task, the authors reported high agreement amongst observers in five distinct cultures (New Guinea, Borneo, the United States, Brazil, and Japan), concluding that their selected stimulus set accurately captured "pan-cultural elements in facial displays of affect" (Ekman et al., 1969, p. 164). As a result, Ekman and Friesen produced a standardized stimulus set designed to accurately portray the universal facial expressions of the six basic emotions—the Pictures of Facial Affect (POFA; Ekman & Friesen, 1976b).

Specifically, standardized universal facial expressions were selected based on their correspondence to theoretically derived facial movement patterns (Ekman, Friesen, & Hagar, 1978, p. 174; Ekman & Friesen, 1975) as measured by the

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[1] The procedure used to select "pure" facial expressions of primary emotions—the Facial Affect Scoring Technique (FAST; Ekman, Friesen, & Tomkins, 1971)—was unpublished at the time, and comprised a theory-based selection of Action Unit patterns.

Facial Action Coding System (FACS; Ekman & Friesen, 1976a)—an objective system that comprehensively describes all visible facial movements (both static and dynamic) with reference to functionally anatomical facial muscle movements called Action Units (AUs). Offering rigorous levels of stimulus control, "FACS-coded" facial expression stimuli[2] fast became the gold standard in research across broad fields including cultural (Izard, 1994; Matsumoto & Willingham, 2006, 2009), clinical (Berenbaum & Oltmanns, 1992; Keltner, Moffitt, & Stouthamer-Loeber, 1995), developmental (Matsumoto, Haan, Yabrove, Theodorou, & Carney, 1986) and health psychology (Rosenberg, Ekman, & Blumenthal, 1998), neuroscience (Adolphs, Spezio, Parlier, & Piven, 2008; Furl, Van Rijsbergen, Treves, Friston, & Dolan, 2007; Morris et al., 1998; Schyns, Petro, & Smith, 2007, 2009; van Rijsbergen & Schyns, 2009), perception and visual cognition (Phelps, Ling, & Carrasco, 2006; Smith & Schyns, 2009; Smith, Cottrell, Gosselin, & Schyns, 2005), and computational modelling (Dailey et al., 2010). With subsequent replications across other cultures (e.g., Ekman, 1972; Izard, 1971)[3], the field largely concluded that facial expressions are universally expressed and recognized (see Izard, 1994, for a review).

At this stage, it's useful to return to the framework illustrated in Figure 2. Specifically, FACS-coded (i.e., universal) facial expressions were widely accepted as the signals that accurately communicate the six basic emotion categories (i.e., the message) across cultures based on the decoding (i.e., recognition) performance of observers. Yet, such claims cannot be substantiated for a number of reasons.

Universal recognition of facial expressions—a closer look

First, the design of choice to test the universal recognition of facial expressions is the *n*-Alternative Forced Choice task (AFC, e.g., $n = 6$ where the six basic emotions are included), where observers typically view a limited set of prescribed (i.e., FACS-coded) facial expression signals and categorize each according to a prescribed set of emotion labels. Recognition (i.e., decoding)

[2] FACS-coded facial expression stimuli include the following datasets: Japanese and Caucasian Facial Expressions of Emotion (JACFEE; Matsumoto & Ekman, 1988), the Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998), the Radboud Faces Database (RaFD; Langner et al., 2010), Pictures of Facial Affect (POFA; Ekman & Friesen, 1976b), Unmasking the Face-photo set (Ekman & Friesen, 1975), and Montreal Set of Facial Displays of Emotion (MSFDE; Beaupré, Cheung, & Hess, 2000).

[3] Although Ekman (1968, 1970) and Friesen (1972) are widely cited in support of universality (e.g., Ekman, 1972; Ekman & Friesen, 1971; Ekman et al., 1987; Ekman, Rolls, Perrett, & Ellis, 1992), each lack peer review, with the last comprising an unpublished doctoral dissertation.

accuracy for each emotion category is then calculated as proportion (i.e., hit rate) with (universal) recognition typically concluded if accuracy exceeds chance performance (16% in 6AFC designs or 14% in 7AFC designs, e.g., Biehl et al., 1997; Boucher & Carlson, 1980; Matsumoto, 1992; Matsumoto et al., 2002; Shimoda, Argyle, & Ricci Bitti, 1978). Yet, implementations of the *n*AFC design and subsequent analysis limit the validity of the conclusions drawn. For example, calculating accuracy based on the proportion of correct responses (i.e., hit rate), and assuming no response bias (i.e., uniform distribution of responses across categories) increases Type I errors, thereby jeopardizing the validity of the conclusions drawn (Macmillan & Creelman, 2004; Wagner, 1993). Given that the vast majority of work supporting the universality hypothesis is based on uncorrected accuracy scores, their conclusions should be interpreted with caution.

Importantly, although modelling response biases in *n*AFC designs is complex (see DeCarlo, 2012), response biases can be examined by analysing error patterns—i.e., systematic confusions between emotion categories, as represented by an $n \times n$ confusion matrix (e.g., Damjanovic, Roberson, Athanasopoulos, Kasai, & Dyson, 2010; Elfenbein, Mandal, Ambady, Harizuka, & Kumar, 2002; Haidt & Keltner, 1999; Jack, Blais, Scheepers, Schyns, & Caldara, 2009). In addition to reflecting expectations of the transmission frequency of facial expression signals based on experience (e.g., Tomkins & McCarter, 1964), and attributional style (e.g., Crick & Dodge, 1994), error patterns could provide insights into the costs associated with recognition error (e.g., high cost of failing to detect a signal could increase sensitivity and therefore false alarms).

Second, the criteria used to demonstrate universal recognition—above chance performance not only fails to acknowledge response bias, but is too insensitive to identify the systematic cultural differences in recognition accuracy reported in all such studies (e.g., Biehl et al., 1997; Boucher & Carlson, 1980; Ducci, Arcuri, & Sineshaw, 1982; Ekman, 1972; Ekman et al., 1969, 1987; Elfenbein & Ambady, 2003; Elfenbein, Mandal, Ambday, Harizuka, & Kumar, 2004; Huang, Tang, Helmeste, Shioiri, & Someya, 2001; Jack et al., 2009; Kirouac & Dore, 1985; Kirouac & Doré, 1983; Matsumoto & Ekman, 1989; McAndrew, 1986; Shioiri, Someya, Helmeste, & Tang, 1999). Figure 3 illustrates the variation in facial expression recognition accuracy across cultures using data extracted from these studies. Colour-coded circles located on geographical regions the recognition performance of observers categorizing the six "universal" facial expressions. Note the considerable variation in recognition accuracy across cultures. For example, whereas Westerners recognize all six facial expressions with high accuracy (typically >75%, e.g., see magenta circles in North America, UK), other cultures show significantly lower performance for disgust, anger, and fear (e.g., note the higher concentration of circles outlined in black, denoting <75% accuracy. See Elfenbein & Ambady, 2002b, for a meta-analysis; see Mesquita & Frijda, 1992, and Russell, 1994, for reviews). Similarly, above chance

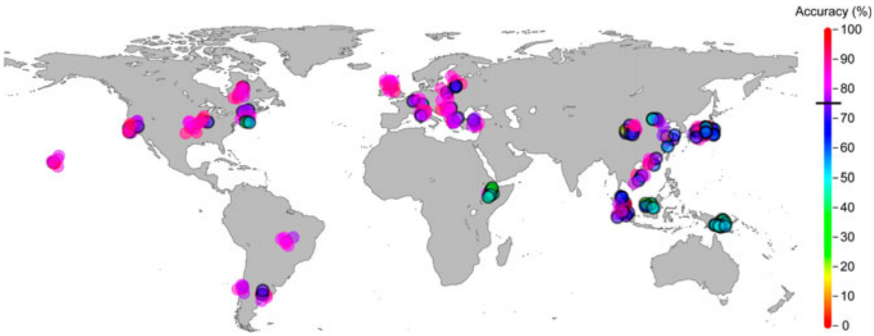

Figure 3. Mean recognition accuracy of the six "universal" facial expressions of emotion across cultures. Colour-coded circles represent the mean recognition accuracy (%) of observers in different regions of the world categorizing the six "universal" facial expressions of emotion. Each colour-coded circle represents one of the six facial expressions (not indicated) with accuracy indicated by a different colour (see colourbar on the right). Circles outlined in black indicate recognition <75% accuracy. Note that recognition accuracy in North America, for example, ranges between 100% (magenta) and 70% (dark blue). In contrast, recognition accuracy in New Guinea ranges from 100% to 30% (green). Data are extracted from several well-known studies reporting universal recognition of six basic facial expressions of emotion (e.g., Biehl et al., 1997; Boucher & Carson, 1980; Ducci et al., 1982; Ekman, 1972; Ekman et al., 1969, 1987; Elfenbein & Ambady, 2003; Elfenbein et al., 2004; Huang et al., 2001; Jack et al., 2009; Kirouac & Doré, 1983; Kirouac & Dore, 1985; Matsumoto & Ekman, 1989; McAndrew, 1986; Shioiri et al., 1999). To view this figure in colour, please see the online issue of the Journal.

performance is an inappropriate measure as it does not reflect typical recognition (i.e., the clinical defintion of recognition is ~75% accuracy; see Duchaine & Nakayama, 2006). As Figure 3 illustrates "universal" FACS-coded facial expressions do not elicit similar levels of recognition across cultures. Rather, on closer inspection, a smaller subset of facial expressions—namely happy, surprise, sad, and anger—are recognized using criterion typically used in visual cognition (e.g., Gosselin & Schyns, 2001). Furthermore, certain facial expressions are systematically miscategorized in some cultures—e.g., amongst East Asian observers, fear is typically miscategorized as surprise, and disgust as anger (Jack et al., 2009; Matsumoto & Ekman, 1989; Moriguchi et al., 2005).

A further criticism is that typical *n*AFC designs are too underspecified to adequately characterize the response (i.e., perception of emotion) in relation to the signal (i.e., facial expression). First, as discussed extensively by Russell in his seminal work (1994), use of a limited and prescribed set of response categories can misrepresent the observers perceptual judgement by coercing responses into a single, ill-fitting category (in the absence of an "other/none of the above" option; see also Russell, 1993). Furthermore, response categories (i.e., emotion labels) are typically prescribed in a top-down manner by experimenters, thereby masking the true perceptual categories of emotion in any culture (Haidt & Keltner, 1999; Russell & Yik, 1996).

A popular alternative to *n*AFC designs is free labelling (Boucher & Carlson, 1980; Darwin, 1872/1999; Frijda, 1953; Izard, 1971; Russell, Suzuki, & Ishida, 1993; Sorenson, 1976), which, without prescriptive emotion categories, should avoid these issues. Thus, if universal facial expressions accurately represent the six basic emotions, observers should spontaneously label them as such. However, mixed results, either supporting (e.g., Boucher & Carlson, 1980) or challenging (e.g., Russell et al., 1993) the universality hypothesis, are likely due to differences in criteria for "correct" responses, varying from loosely related words (e.g., Izard, 1971) to strict synonyms (e.g., Ekman & Friesen, 1988; see Russell, 1994). Without an objective measure of conceptual similarity between emotion words within a culture, criteria for conceptual similarity are typically based on the judgement of the experimenter, rather than the observer, which is of course not immune to cultural biases. Also, in free labelling designs, the experimenter typically groups the freely provided labels into a prescribed set of emotion categories defined by the experimenter, thereby imposing the same category biases as that of *n*AFC designs. As a result, the number and nature of primary emotion categories relevant in each culture could be misrepresented, thereby masking any potential similarities and differences in the conceptual landscape of emotion categories. Thus, although free labelling represents an important step towards a more comprehensive representation of the response space, implementations of analyses limit its potential to map and reveal cultural similarities and differences in emotion communication.

Cultural differences in decoding facial expressions of emotion

As demonstrated, closer inspection of data collected over 40 years of recognition research shows that "universal" facial expressions are not universally recognized, with reported accuracy rates requiring a more cautious interpretation. To appreciate the implications of these results within the framework of communication, consider the relationship between signalling and decoding illustrated in Figure 2. Specifically, low recognition accuracy could be due to (1) an impediment in the transmission of the signal (i.e., facial expression) such as a distortion or suppression, or (2) a decoding process that is inadequate to accurately reconstruct the intended message from the signal.

With such observations well documented, several reviews of the literature (Elfenbein & Ambady, 2002b; Mesquita & Frijda, 1992; Russell, 1994) generated a number of theoretical accounts (Elfenbein & Ambady, 2002a; Elfenbein, Beaupre, Levesque, & Hess, 2007; Matsumoto & Ekman, 1989) proposing that cultural variation in facial expression recognition is due to differences in decoding processes modulated by learning. Importantly, such theories also reflect the intimate relationship between signalling (i.e., production) and decoding (i.e., perception). For example, building on Tomkins' innate, subcortical Facial Affect Programme theory (Tomkins, 1962, 1963), Ekman's neurocultural framework proposed that culture-specific display rules (Buck, 1984) could diminish the transmission of certain instinctual facial expression signals, thereby reducing observers' expertise in decoding innate facial expressions and therefore recognition performance (Ekman, 1972). Culture-specific accents (Marsh, Elfenbein, & Ambady, 2003) or dialects (Elfenbein, 2013; Elfenbein et al., 2007; Tomkins & McCarter, 1964) could introduce specific variations in common facial expression signals, rendering accurate interpretation (i.e., decoding) more difficult for outgroup compared to ingroup members—i.e., the ingroup advantage (Elfenbein & Ambady, 2002a; Tomkins & McCarter, 1964). Similarly, in line with the Other Race Effect (ORE) literature, a lack of experience with or motivation to process other-race (i.e., outgroup) faces could lead to a subsequent lack of expertise in decoding other-culture facial expressions (e.g., Hugenberg, Miller, & Claypool, 2007; see O'Toole & Natu, this issue 2013; Pauker et al., 2009; Rhodes, Tan, Brake, & Taylor, 1989; Tanaka, Kiefer, & Bukach, 2004). Culture-specific decoding rules, which actively discourages explicit acknowledgement of certain facial expressions (e.g., recognizing anger, but reporting the more socially acceptable emotion, sad), could also give rise to culturally biased response patterns rather than reflecting lower recognition accuracy per se (Buck, 1984; Matsumoto, 1992; Matsumoto & Ekman, 1989). Yet, a direct account of the origins of cultural differences in facial expression recognition and systematic confusions between emotion categories (Tomkins & McCarter, 1964) remained largely unexplained, as reflected in *Emotions Revealed*: "To this day, I do not know why fear and surprise [are] not distinguished from each other" (Ekman, 2007, p. 6).

To address this question, Jack and colleagues used a combination of behavioural and spatiotemporal eye movement analyses, and statistical modelling to examine the decoding of "universal" facial expressions amongst East Asian and Western Caucasians (Jack et al., 2009). Figure 4 summarizes the results. Using the six "universal" facial expressions (selected from the JACFEE database),[4] Jack et al. (2009) replicated the significant cultural differences in recognition performance reported in the literature—Westerners recognized all six facial expressions with comparably high accuracy, whereas East Asians systematically miscategorized fear and disgust (see red bars in Figure 4, Fixation patterns), confusing them with surprise and anger, respectively. Precision eye-tracking technology and spatiotemporal/information-theoretic based analyses

[4] As detailed in Jack et al. (2009), East Asian participants comprised primarily Chinese nationals. Given that Chinese observers show no other-race effect when viewing Japanese faces from the JACFEE database (O'Toole, Deffenbacher, Valentin, & Abdi, 1994), Japanese and Chinese can therefore be considered—in the context of perception—"same race" (see Little & Sussman, 2010, for the history of the concepts of race).

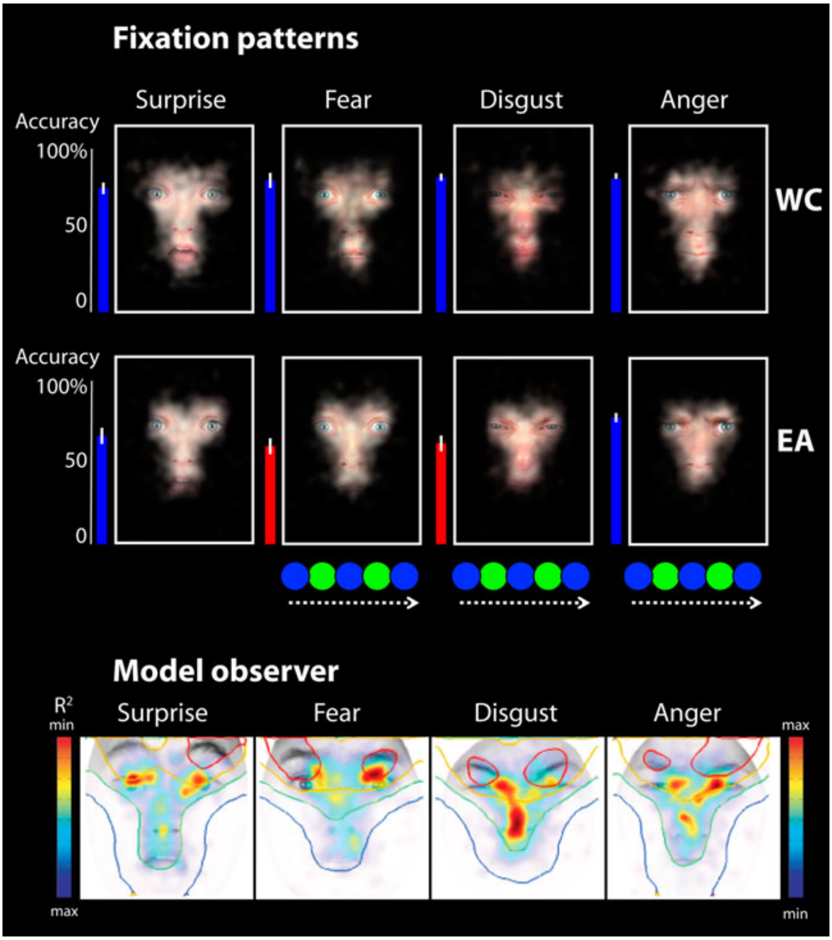

Figure 4. Sampling of face information during decoding of the six "universal" facial expressions of emotion in Western Caucasian and East Asian observers. A subset of the results is presented here for brevity, with all results extending to all six facial expressions of emotion. Fixation patterns. Colour-coded bars show that Western Caucasian (WC) observers accurately recognize all facial expressions (see blue bars). In contrast, East Asian (EA) observers show significantly lower recognition accuracy for fear and disgust (see red bars), confusing them with surprise and anger, respectively. As illustrated by each face, WC observers distribute fixations across the face, sampling information from the eyes and mouth. In contrast, EA observers repetitively sample eye information (see colour-coded circles representing left and right eye regions), particularly for confused expressions. Note the similarity in eye information between surprise and fear, and anger and disgust. Model observer. To objectively test whether sampling ambiguous eye information could give rise to the EA behavioural confusions, Jack et al., (2009) built a model observer that samples information from the face to categorize facial expressions. By mirroring the behavioural confusions of the EA observers, the model observer produced a sampling bias towards the eyes and eyebrows (areas delimited in red and orange indicate the "best fit" face regions, see scale on left). Note the higher density of EA observer fixations (represented by red areas, see scale on right) within face regions ranked as "best fit". This demonstrates that the behavioural confusions of the EA observers are symptomatic of an information sampling strategy that selects ambiguous information (i.e., the eyes and eyebrows) while neglecting more diagnostic features (i.e., the mouth). To view this figure in colour, please see the online issue of the Journal.

(Minimum Description Length [MDL]; Rissanen, 1989) routinely used in genetics (Chaitankar et al., 2010; Dougherty, Tabus, & Astola, 2008; Zhao, Serpedin, & Dougherty, 2006) showed that Westerners distribute fixations across the face, thereby sampling information from the eyes and mouth (Figure 4—Fixation patterns, top row). In contrast, East Asians primarily fixate the eye region while neglecting the mouth, including repeated sampling of the eyes while decoding facial expressions that elicited systematic confusions (Figure 4—Fixation patterns, bottom row see colour-coded circles representing left and right eye regions).

To objectively examine whether sampling the eye region while neglecting diagnostic information (i.e., the mouth for fear and disgust; see Smith et al., 2005) could give rise to the behavioural confusions (in Figure 4—Fixations patterns, bottom row, note the similarity of the eye information between fear and surprise, and disgust and anger), Jack and colleagues built a model observer that samples information from a face to categorize emotions. As shown in Figure 4—Model observer, sampling the eye region gives rise to a pattern of confusions most similar to the East Asian behavioural pattern of confusions (delimited in red and orange). For the first time, Jack and colleagues show that the East Asian systematic confusions are due to a decoding strategy that is inadequate to reliably distinguish certain expressions due to repetitively sampling ambiguous eye information that neglects the diagnostic mouth (see Figure 4—Fixation patterns). By providing an objective account of the significant cultural differences in the recognition of "universal" facial expressions, Jack et al.'s work highlights clear cultural specificity in the decoding—i.e., information extraction—of facial expression signals (see also Yuki, Maddux, & Masuda, 2007).

Together, data from the recognition (i.e., decoding) literature questions long-standing notions that humans can accurately communicate six emotion categories across cultural boundaries using a prescribed set of facial expression signals. Several questions are therefore raised regarding both the signalling and decoding of facial expressions. First, "universal" facial expression signals such as fear and disgust consistently elicit significantly lower recognition performance in East Asian compared to Western groups. Yet, the accurate decoding of emotion is an essential social skill necessary in all cultures, with fear and disgust representing "primitive" emotions, as reflected by their biological origins (e.g., Susskind et al., 2008) and association with rapid deep brain activity (e.g., amygdala; Whalen et al., 2004; Liddell et al., 2005; Morris et al., 1996; Ohman & Mineka, 2001, Phillips et al., 1997, but see also Du & Martinez, 2013 and Pessoa & Adolphs, 2010 for a discussion). How then do East Asian cultures signal these emotions with the face? Second, why would East Asian observers repetitively sample ambiguous information while neglecting more objectively informative face regions when decoding facial expressions? To achieve accurate communication, observers in any culture should extract and decode the task-relevant face information to accurately reconstruct the intended message. To address these questions, Jack and colleagues harnessed the power of subjective perception to model the mental representations of the six basic facial expressions of emotion in Western Caucasian and East Asian observers (Jack, Caldara, & Schyns, 2011; Jack et al., 2012).

THE LINK BETWEEN FACIAL EXPRESSION SIGNALLING AND DECODING

At this juncture, it is important to first highlight the relevance of mental representations in understanding the system of facial expression signalling and decoding, and secondly how perception (i.e., a product of decoding) can be used to model the signals certainly expected and possibly transmitted in the external environment. To do so, let us return to the signalling and decoding framework illustrated in Figure 2.

Mental representations—knowledge, concepts, and unconscious inference

On receiving a signal, observers (B) decode the message by extracting the task-relevant information and performing an interpretation (i.e., categorical perception) based on top-down information (i.e., prior knowledge), also known as mental representations. Built from previous experiences interacting with the external environment, mental representations reflect the conceptual knowledge acquired to provide predictive information about the world, and thereby shaping expectations and guiding behaviour. Thus, an observer's interpretation (i.e., decoding, categorical perception) of a signal reflects their prior knowledge of that signal as transmitting a specific message.

The importance of the development of conceptual knowledge (i.e., mental representations) on cognition and behaviour is beautifully illustrated in the classic study of Inhelder and Piaget (1958). Children, with their limited knowledge of the physical world, tend to mistakenly predict that a small metal nail will float and a large wooden block will sink, based on object size rather than the influence of material properties on buoyancy (Inhelder & Piaget, 1958). Thus, without a suitably comprehensive understanding of the physical environment (i.e., conceptual knowledge), children are unable to accurately predict certain outcomes. By interacting with the environment, knowledge is subsequently acquired and consolidated into concept—a complex unit of information about an object—that is retained as a mental representation for future use in predicting and interpreting (i.e., decoding) the environment (Murphy, 2004).

Correspondingly, as originally discussed by von Helmholtz (1867/2005), visual perception is not a direct translation of the visual environment, but created by combining visual information captured by the retina with assumptions based on prior experience/knowledge (i.e., mental representations, termed "unconscious inference"; see Yuille & Kersten, 2006, for more recent developments). Visual illusions such as the famous Checker-shadow illusion (Adelson, 1995) provide some of the best demonstrations of how visual perception reflects prior knowledge. Here, the Checker-shadow illusion demonstrates that prior knowledge of the effects of objects casting shadows (i.e., that shadows darken objects) distorts reality, resulting in the perception that two squares have different shades when they are in fact identical. Thus, information extracted by the visual system can be subject to different interpretations (i.e., decoding), depending on the knowledge and experience acquired (see Schyns & Rodet, 1997, for effects of learning on perception; Wisniewski & Medin, 1991).

Davidoff, Davies, and Roberson (1999) show a clear example of the influence of culture-specific knowledge on the decoding of visual information by demonstrating cultural specificity in colour categorization. Using colour chips from the Munsell colour system, English-speaking and Berinmo (of Papua New Guinea) observers categorized each colour chip according to the colour terms used in their respective cultures (i.e., English speakers used eight colour categories—red, pink, orange, yellow, green, blue, purple, and brown, whereas the Berinmo used five—wapa, mehi, wor, nol, and kel). Examination of the categorical perception of colour revealed a clear cultural difference whereby each group dissected the colour-space using a set of culture-specific categorical[5] perceptual boundaries. For example, whereas English speakers distinguished between blue and green colour chips, the Berinmo made no such distinction. Similarly, whereas the Berinmo distinguish between nol and wor, English speakers make no such distinction (Davidoff et al., 1999). Importantly, as demonstrated in earlier works (Goldstone, Steyvers, & Larimer, 1996), these data show that learned concepts—i.e., mental representations of specific colours and their associated categorical labels, thereby producing categorical perception—exert a powerful influence upon visual perception itself (see also Roberson, Davidoff, Davies, & Shapiro, 2005; Roberson, Davies, & Davidoff, 2000). Specifically, categorical perception creates the perceptual illusion that within category items are more similar than between category items, even when the physical difference between exemplars is equal (Goldstone et al., 1996).

As illustrated, culture exerts a powerful influence upon the human visual system: culture-specific knowledge and conceptual frameworks (i.e., mental representations) created from experiences interacting with the world, shape categorical perception (i.e., decoding), thereby laying down specific perceptual boundaries on the visual environment, as demonstrated by relative size judgements (Davidoff, Fonteneau, & Goldstein, 2008), change blindness sensitivities (Masuda & Nisbett, 2006), categorical reasoning styles (Norenzayan, Smith,

[5] The Berinmo and English groups provided judgements of categorical rather than physical similarity.

Kim, & Nisbett, 2002), and eye movements (Blais, Jack, Scheepers, Fiset, & Caldara, 2008; Kelly, Miellet, & Caldara, 2010). Thus, modelling the mental representations of facial expressions (i.e., concepts acquired from interacting with the environment) across cultures can reveal the specific face signals that observers associate with specific emotion categories (i.e., message) based on past experience and therefore reflecting future expectations.

The coevolution of facial expression signalling and decoding

How can perception be used to model the signals transmitted in the external environment? To understand this link, let us return again to Figure 2, which illustrates the intimate relationship between the signalling and decoding of information. As social signals, the central purpose of a facial expression is to reliably communicate specific information (e.g., internal emotional states and/or external environmental conditions) between a sender (A) and receiver (B; but see Dawkins & Krebs, 1978, for cheating). To achieve near optimal communication,—i.e., successful receipt and decoding of the message by the observer—signals are designed in accordance with the coevolving decoding sensitivities of the receivers perceptual system (see also Gerhardt, 1983, for other influential factors such as environmental conditions) as part of an "evolutionary game" (Maynard Smith, 1982). Thus, probing the decoding sensitivities of a perceptual system (i.e., the receiver) can inform the signals they are evolved to detect and decode (Lennie, 2003). With such profound theoretical significance, the intimate link between signalling and decoding is shared across biological signalling (Arak & Enquist, 1993; Guilford & Dawkins, 1991), generative grammars and the finite automata counterpart (Chomsky, 1969), pattern recognition theory (Grenander & Miller, 2007), and Kersten and Yuille's recent hierarchical Bayesian models (Kersten, 2003; Yuille & Kersten, 2006).

By virtue of this link, several ground-breaking studies combined neurophysiology, psychophysics, and statistical image processing to provide fundamental knowledge of visual information signalling and decoding. First, several early works revealed the specific sensitivities (i.e., specialization) of the visual brain to decode the relevant visual information transmitted in the environment. For example, in their seminal work, Hubel and Wiesel (1959) first showed that specific populations of cells in V1 (primary visual cortex) are maximally sensitive to differing levels of signal complexity. Similarly, Maffei and Fiorentini (1973) revealed that dedicated regions of the visual brain decompose signals into different spatial frequencies (see also De Valois, De Valois, & Yund, 1979; Maffei & Fiorentini, 1973). Later, Schyns, Petro & Smith (2007, 2009) show, in a series of works, correspondence between visual decoding specialization and facial expression signal design, supporting co-evolutionary accounts and therefore the link between facial expression signalling (i.e., production) and decoding (i.e., perception).

Specifically, each of the six basic facial expression signals comprise decorrelated diagnostic information (Smith et al., 2005)—i.e., they are designed with minimal signal overlap, enabling near-optimal categorization with minimal confusion (Fechner, 1860; Swets & Green, 1964). With corresponding decorrelated brain signals, such signals are easily discriminated (i.e., decoded) by the human visual brain (Smith et al., 2005). Furthermore, the sensitivity of the visual system to detect different spatial frequencies across specific distances, coupled with the spectral composition of the diagnostic information required to recognize (i.e., decode) each facial expression signal, certain facial expressions are recognizable at different viewing distances. For example, whereas the large-scale smiling mouth in happy (i.e., low spatial frequency information) is visible across a wide range of viewing distances, the fine-scale nose wrinkles required for disgust (i.e., high spatial frequency information) are only visible at closer viewing distances (Smith & Schyns, 2009). Thus, in line with biological signalling accounts, the design of diagnostic signals could confer information about proximity (e.g., disgust could indicate a proximal threat such as the slow dispersion of pathogens with limited trajectory). Similarly, the vertical location of diagnostic face information predicts the speed of neural processing, which could provide information about immediacy. For example, accurate decoding of fear using the eyes (located higher in the face) is associated with an earlier N170 peak compared to happy, which relies on the mouth (located lower in the face; see Schyns et al., 2007). Together, these data support coevolutionary accounts of biological signalling by showing a close correspondence between signal design and receiver decoding specialism, thereby highlighting the fundamental link between signalling and decoding.

SIGNALLING

Culture-specific mental models of facial expression signals

As demonstrated signalling (i.e., production) and decoding (i.e., perception) are intimately linked. Therefore, by probing the "receptive fields" of perception (i.e., decoding), we can model the signals expected by the observer and possibly transmitted in the environment that the perceptual system has coevolved to decode. That is, by harnessing the power of subjective perception we can model the mental representations (i.e., prior knowledge) of facial expression signals in individual observers, and the perceptual boundaries under which the visual world is divided (e.g., see Davidoff et al., 1999). Using an approach based on Chomsky's generative grammars (Chomsky, 1969) and Ulf Grenander's "General Pattern Recognition Theory", which builds on the predicate that a system will only recognize what it can internally synthesize (Grenander & Miller, 2007), combined with a well-known psychophysics technique—reverse correlation (Ahumada & Lovell, 1971)—Jack and colleagues probed the "receptive fields" of facial expression categorization in two complementary studies (Jack et al., 2011, 2012). Each will be summarized next.

Using uniform pixel white noise, Jack and colleagues modelled the mental representations of six facial expressions of emotion (happy, surprise, fear, disgust, anger, and sad) in Western and East Asian observers (Jack et al., 2011). Figure 5 illustrates the procedure and summarizes results. On each trial, a white noise template is added to a neutral face, producing a perceptively different stimulus. Naïve observers categorize each stimulus according to the six basic emotion categories (plus "don't know") if the pattern correlates with their mental representation of that facial expression signal (e.g., anger, see Figure 5, Design). Thus, the white noise template captures the information that must be added to the neutral face for the observer to perceive a specific facial expression. To extract the information consistently associated with the perception of each facial expression, the corresponding white noise templates were averaged across trials for each observer separately (see Figure 5, Analysis; see also Dotsch, Wigboldus, Langner, & van Knippenberg, 2008; Gosselin & Schyns, 2003; Kontsevich & Tyler, 2004 for additional examples of the technique).

Cross-cultural comparison of the resulting mental models of facial expression signals revealed that Westerners and East Asians expect expressive information to be located in different face regions—whereas Westerners expect expressive features to be located across the eyes and mouth regions, East Asians expect expressive information to be located primarily in the eye region (see Figure 5, Results). Closer inspection further revealed that East Asian observers expect distinct eye gaze directions, whereas Westerners do not. Correspondence between the expected location of expressive information and fixation patterns previously reported (Jack et al., 2009) demonstrate the role of top-down information (i.e., mental models) on the operation of biological visual systems used to extract information from signals transmitted in the environment. Consequently, East Asian culture-specific expectations of expressive information account for the repetitive sampling of (unexpectedly) ambiguous eye information and subsequent behavioural confusion when decoding "universal" facial expressions (diagnostic information is located in the mouth; see Smith et al., 2005). Together, these data show that culture shapes the mental models (i.e., expectations) of facial expression signals, challenging universality and further explaining the origins of the systematic East Asian behavioural confusions reported in the literature.

Given that facial expressions are highly dynamical signals (Jiang, Valstar, & Pantic, 2011; Krumhuber et al., 2013), Jack and colleagues built on the previous results by combining reverse correlation and a unique four-dimensional Generative Face Grammar (GFG; Yu, Garrod, & Schyns, 2012) to model the three-dimensional dynamic mental models of six facial expressions of emotion in Western and East Asian observers (Jack et al., 2012). Figure 6 illustrates the

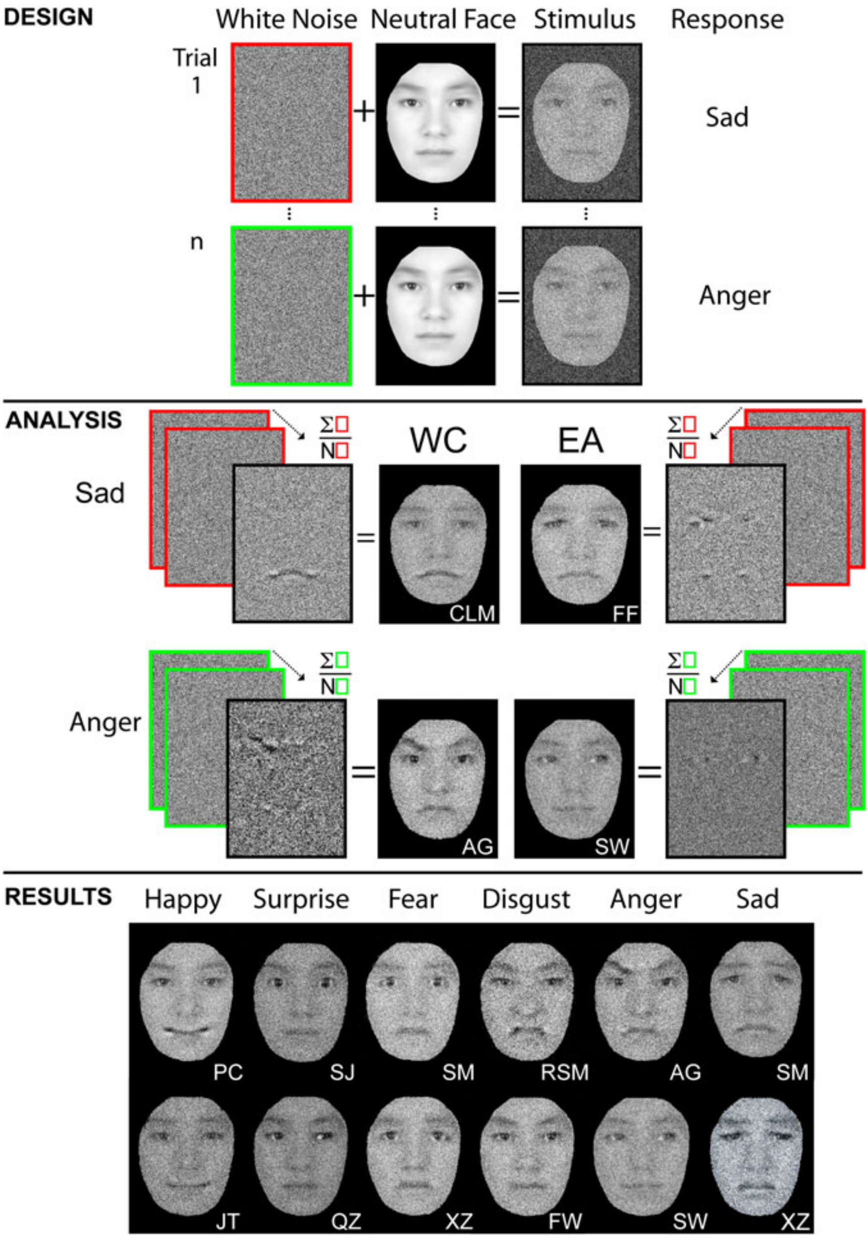

Figure 5. Reverse correlating culture-specific perceptual expectations of facial expressions using a neutral face, plus noise. Design: Stimulus generation and task. On each trial, a white noise template is added to a neutral face. Naïve observers categorized each stimulus according to the six facial expressions of emotion (i.e., happy, surprise, fear, disgust, anger, and sad) plus “don’t know”. Analysis: Reconstruction of

procedure and summarizes the results. On each trial, the GFG randomly selects, from a core set of 41, a set of AUs (in Figure 6A—Generative Face Grammar, see the colour-coded AU labels) and values for six temporal parameters (amplitude, acceleration, deceleration, offset/onset/peak latency; in Figure 6, see colour-coded curves), thereby producing a random facial animation. Naïve observers categorize the facial animation according to the six basic emotion categories (happy, surprise, fear, disgust, anger, and sad), plus "don't know" and by intensity if the facial movements correspond with their mental representation of that facial expression (e.g., here, disgust, medium intensity; see Figure 6A—Mental representations). To model each observer's dynamic mental representations of the six facial expressions at each level of intensity, the observer's responses are reverse correlated with the AUs and temporal parameters. Spatiotemporal analysis of the models revealed that East Asians uniquely represent emotional intensity with early eye region activity (Figure 6D—Temporal dynamics). Furthermore, information-theoretic based (mutual information, see Figure 6C—Mutual information) and clustering analyses (*k*-means) revealed that whereas Western facial expression models form six distinct and emotionally homogenous clusters, supporting notions of six primary emotion categories (Ekman, 1992a, 1992b; Ekman & Cordaro, 2011; Ekman et al., 1969; Levenson, 2011; Tomkins, 1962, 1963), East Asian models do not (see Figure 6B—Facial movement clusters). Specifically, whereas East Asian models of happy and sad form two distinct clusters, models of surprise, fear, disgust, and anger overlap between categories. Together, these results challenge the universality of facial expressions of emotion and the notion that human emotion is universally comprised of six primary emotion categories.

ARE FACIAL EXPRESSIONS UNIVERSAL?

Here, I have highlighted the major advances in understanding facial expression signalling and decoding across cultures. Although some support the notion of universality (e.g., Darwin, 1872/1999; Ekman et al., 1969; Shariff & Tracy, 2011; Susskind et al., 2008), others support cultural specificity (e.g., Elfenbein, 2013; Jack et al., 2009, 2012; Russell, 1994). To accurately interpret and

culture-specific perceptual expectations. For each observer and facial expression separately, the set of white noise templates associated with the observer's categorization responses (e.g., sad colour-coded in red and anger colour-coded in green) are averaged to. 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: Culture-specific perceptual expectations. Each row represents the cultural expectations of six facial expressions of emotion, each selected from a different observer. WC observers expected expressive information in the eyes and mouth, whereas EA observers expected expressive information to be in the eyes, with distinct changes of gaze direction. To view this figure in colour, please see the online issue of the Journal.

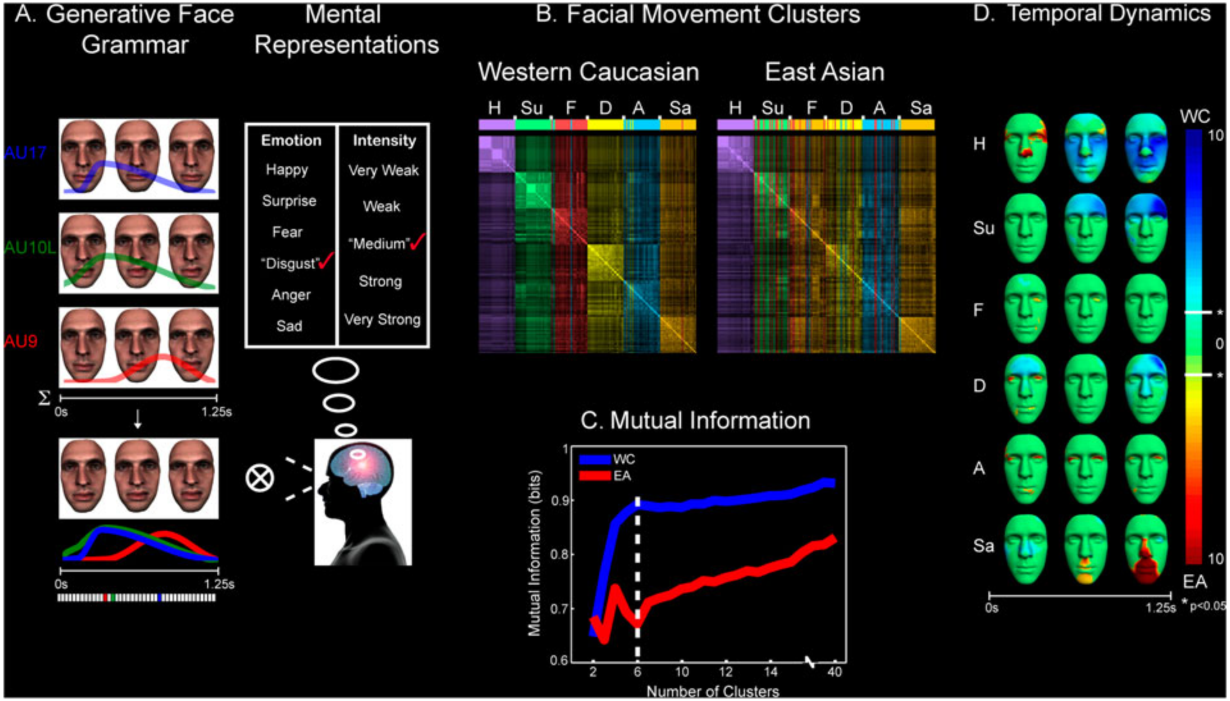

Figure 6. Computing culture-specific dynamic mental representations of facial expressions. (A) Generative face grammar. Random facial animation comprising three muscle groups (Action Unit, AU, 17 = blue; 10L = green; 9 = red). Observers categorize the random animation by emotion ("happy", "surprise", "fear", "disgust", "anger", and "sad", plus "don't know") and intensity (from "very strong" to "very weak"). Mental representations. To construct each observer's mental models, the facial movements are reverse correlated with the observer's responses. (B) Facial movement clusters. Cross-correlation matrices of the 180 Western Caucasian (WC) and 180 East Asians (EA) models. Each model is colour-coded by cluster assignment (K-means clustering analysis; $k = 6$). Clustering analysis shows that only WC models form six distinct and emotionally homogeneous groups (see colour-coded cluster assignments). (C) Mutual information. K-means clustering ($k = 2$ to 40 centroids) revealed that six clusters are optimal for WC models. For the EA models, no homogeneous clustering existed. (D) Temporal dynamics. Signalling of emotional intensity over time differs across cultures (blue = WC-specific; red = EA-specific). To view this figure in colour, please see the online issue of the Journal.

integrate these findings into current knowledge of emotion communication, I will review a number of relevant considerations.

Fewer than six universal facial expressions?

Support for the universality hypothesis primarily cites universal facial expression recognition (i.e., decoding, e.g., Ekman et al., 1969). Yet, only a subset of the six "universal" facial expressions is universally recognized (i.e., namely happy, surprise, anger, and sad) suggesting a universal language of fewer than six facial expression signals (see also Sauter, Eisner, Ekman, & Scott, 2010, for evidence of cultural specificity and universality in emotion vocalizations). Interestingly, this subset does not include the facial expression signals of fear and disgust, although both are largely considered to be "primitive" on the basis of their biological origins (e.g., Susskind et al., 2008) and association with rapid deep brain activity (e.g., Whalen et al., 2004, but see also Pessoa & Adolphs, 2010 for a discussion). Instead, low (but significantly above chance) recognition of "universal" facial expressions suggests that these signals contain *elements* of universal signals of emotion. For example, consider a facial expression of the Oryia women in Bhubaneswar, India where "the tongue extends out and downward and is bitten between the teeth, the eyebrows rise, and the eyes widen, bulge, and cross" (Shweder, 1991, p. 246). Based on the available information, we would either conclude that the emotion is fear (or surprise) on account of the widened eyes, or disgust based on the protruding tongue. Given that the facial expression represents surprise/embarrassment/fear, accuracy would exceed chance (but not be high enough to support accurate communication). Thus, by extracting the universal elements (e.g., eye widening, eyebrow raising), while ignoring unfamiliar signals (i.e., crossing of the eyes), a basic level of communication could be achieved.

Second, although the biological origins of facial expressions typically support the universality hypothesis, only a few "universal" facial expressions contain biologically rooted signals—i.e., namely fear and disgust (but see Jack et al., 2013, for biologically adaptive movements in surprise and anger). Yet, neither of these "primitive" facial expressions is accurately recognized across cultures[6], contradicting support for their universality. Rather, the specific biologically adaptive facial movements (e.g., eye widening or nose wrinkling) could comprise universal signals that transmit more general information about the external environment (e.g., distal or proximal threat). However, without culturally valid facial expressions available yet for comparison, it remains

[6] Note that Susskind et al. (2008) used fear and disgust facial expression stimuli from the JACFEE database, which, while posed by Western Caucasian, American Japanese, and Japanese nationals, are only recognized by Western observers.

unknown whether the same biologically adaptive movements are present in the facial expressions of other cultures.

Biological origins, culture-specific modulations

A smaller subset of universally recognized facial expressions could reflect the relatively simpler system of emotion communication in early man that remains embedded in the more complex set of signals used by modern man. Specifically, the biologically adaptive function of facial expressions, coupled with their inherent signalling qualities could have given rise to the coevolution of a few highly decorrelated emotion signals that could be easily discriminated by the primitive visual brain (e.g., eye widening and nose wrinkling). With subsequent migration across the world and increasing cognitive complexity and social sophistication (Dunbar, 1993, 1998), facial expressions, like language (Fay, Garrod, Roberts, & Swoboda, 2010), likely evolved from a simpler system into a set of more numerous and complex signals designed to subserve developing communication needs (Darwin, 1872/1999; Hasson, 1997; Hebets & Papaj, 2005; Maynard Smith & Harper, 1995). Indeed, modern man in any culture would certainly require more than a subset of biologically rooted signals or even six primary emotion categories to adequately engage in the complexities of social interaction (e.g., see Cunningham, Kleiner, Bülthoff, & Wallraven, 2004 for conversational expressions). In line with the expertise hypothesis (Tanaka & Taylor, 1991), increasing social expertise *within* cultures could enable more subtle discrimination between the numerous and complex facial expression signals using highly specific diagnostic information. In contrast, increasing cultural diversification across the human population could further specialize emotion communication, thereby reducing clarity of communication *between* cultures. As a result, the facial expressions of modern man could comprise elements of universal signals that support the accurate communication of some emotions across cultures, whereas others reflect the influence of cultural diversification.

Western-specific facial expressions

As reflected by high recognition accuracy, FACS-coded "universal" facial expressions of emotion widely used in research are largely representative of Western facial expression signals, but not other cultural groups. Consequently, the advent of standardized (i.e., FACS-coded) "universal" facial expressions imposed limitations on the development of knowledge of signalling and decoding. Specifically, FACS-coded facial expressions are selected on the basis of their correspondence to theoretically derived AU patterns, which claim to "reliably portray the universal emotions" (Matsumoto et al., 2002). Yet, these claims are not empirically supported. Thus, applying FACS-coding criteria to facial expression stimuli acts as a "cultural eraser" (Elfenbein & Ambady, 2002a), thereby inherently limiting knowledge of facial expression signals within and between cultures to a prescribed and limited set of AU patterns. As a result, widespread use of FACS-coding has impacted on the development of knowledge across broad fields. For example, "universal" facial expressions of fear are typically interpreted as surprise by East Asian observers (Jack et al., 2009; Matsumoto & Ekman, 1989; Moriguchi et al., 2005), thereby limiting knowledge of fear decoding in the East Asian brain. Thus, while much is known about emotion information processing in the Western brain (e.g., Adolphs, Damasio, Tranel, & Damasio, 1996; Morris et al., 1998; Schyns et al., 2007, 2009), comparatively less is known about emotion information processing in the non-Western social brain (e.g., Ambady & Bharucha, 2009; Rule, Freeman, & Ambady, 2011).

Furthermore, culturally biased stimuli can unbalance experimental designs and limit empirical investigation of central questions (Matsumoto, 2002). For example, the ingroup advantage hypothesis posits that observers are more accurate at recognizing facial expressions displayed by same- compared to other-culture members (Elfenbein & Ambady, 2002a; Tomkins & McCarter, 1964), highlighting two relevant sources for identifying ingroup affiliation—race of face and culture-specific facial expression signals. However, with current "universal" (i.e., Western-biased) facial expressions, investigation of this central question remains largely suspended (Elfenbein & Ambady, 2002a). For example, although the JACFEE database (Matsumoto & Ekman, 1988) is equipped to examine the influence of race of face on facial expression recognition, it cannot provide a balanced design as it does not provide "equal emotion-signalling properties across observer cultures" (Matsumoto, 2002, p. 238). That is, although rigorously controlled for sex and race (Japanese and White Caucasian) and *physical* facial expression signals, JACFEE stimuli are *perceptually* different across cultures (i.e., they elicit significantly different recognition accuracy). Thus, potential effects of race on facial expression decoding would be confounded by perceptual inequality (e.g., see Lee, Chiu, & Chan, 2005).

NEW QUESTIONS AND THE FUTURE

As already illustrated, current knowledge of facial expression signalling and decoding raises new questions. Here, I will summarize the main directions of research that could elevate knowledge to reveal the true complexities of emotion communication across cultures.

Refining knowledge of emotion communication

Converging evidence suggests that, whereas some facial expressions are universally recognized (i.e., happy, surprise, anger, and sad), others are not (i.e., fear and disgust), with emerging data showing cultural specificities (i.e., accents) in facial expression signals. Together, these data challenge notions of a universal set of six facial expressions and highlight a more complex system of emotion communication within and between cultures. To precisely understand emotion communication, it is now imperative to identify which specific facial expression signals are universal and support accurate communication across cultural boundaries, and which are culture specific, giving rise to confusions (e.g., which East Asian facial expression signals confuse Western observers, if any?).

In a clever study, Marsh et al. (2003) showed that some universally recognized facial expressions (sad and surprise)[7] contain cultural accents—i.e., culture-specific subtle variations of core signals—that reliably indicate nationality (Marsh et al., 2003). Although the specific expressive face information supporting accurate discrimination of nationality remains unknown, these data demonstrate the embedding of cultural accents in "universal" facial expressions (see also Marsh, Elfenbein, & Ambady, 2007). An interesting question, therefore, is what specific emotion information do cultural accents transmit, if any? For example, culturally accented facial expression signals could provide information above and beyond the primary emotion transmitted, such as specifying valence (e.g., positive vs. negative emotion), to more precisely define the emotion transmitted (e.g., see Sun, Garrod, Schyns, & Jack, 2013, for culture-specific facial expression models beyond the six basic categories).

Converging evidence also questions the notion that human emotion is universally comprised of six primary emotion categories (see Ortony & Turner, 1990, for an excellent discussion on basic emotions). For example, Jack and colleagues show that only happy and sad facial expression models form distinct clusters in both Western and East Asian cultures (East Asian models of surprise, fear, disgust, and anger overlap between categories; Jack et al., 2012). Thus, whereas some emotion categories (e.g., happy, sad) could be conceptualized as similarly distinct across cultures, other emotions could be associated with culture-specific concepts based on the distinct moral, social, and political ideologies that underlie every culture. Indeed, as highlighted earlier, the specific conceptual frameworks of beliefs, knowledge, and values embraced by each culture imposes a profound effect on various fundamental cognitions and behaviours, including biologically based processes (see Nisbett & Masuda, 2003, for a review). Thus, a precise understanding of the conceptual structure of emotion categories, the influence of language and linguistic ability on emotion concepts (e.g., Barrett, Lindquist, & Gendron, 2007; Lindquist, Barrett, Bliss-Moreau, & Russell, 2006; Roberson & Davidoff, 2000) and of facial expression signalling and decoding will provide a more authentic model of emotion communication.

[7] Given that happy was not included in Marsh et al.'s analysis, further work is required to determine whether FACS-coded facial expressions of happy – a universally recognised facial expression – contain cultural accents.

Redressing the balance

Based on long-standing, widely accepted notions of a "universal language of emotion", much of research has used "universal" FACS-coded facial expressions to inform broad fields. However, as described, FACS-coding largely represents Western facial expression signals, thereby limiting and biasing knowledge of the true complexities of facial expressions across cultures and affecting related fields (e.g., social neuroscience). In order to redress the balance and expand scientific knowledge beyond the boundaries of Western, educated, industrialized, rich and democratic (WEIRD) populations (Henrich, Heine, & Norenzayan, 2010), it is imperative to identify facial expression signals that are representative of emotion communication in different cultures. With the advent of new data-driven methods and technology—e.g., the Generative Face Grammar (GFG; Yu et al., 2012)—it is now possible to more comprehensively explore the specific face signals (and their combinations) associated with the perception of different emotion categories across diverse cultures (see also Gill, Garrod, Jack, & Schyns, 2012, for perceptual modelling of social traits). As a result, use of bottom-up (i.e., unbiased) data-driven methods will highlight rather than erase genuine cultural differences and similarities in facial expression signals and their corresponding perceptual categories (i.e., decoding).

In addition to providing an unbiased and comprehensive understanding of the facial expression signals within and between cultures, the development of resulting culturally valid facial expressions, could address several key questions. For example, culturally valid facial expression signals of fear and disgust could provide new neuroscientific knowledge of how the non-Western cultural brain efficiently decodes these emotion signals. Similarly, flexible stimuli could address remaining questions relating to the ingroup advantage. For example, is facial expression decoding modulated by the racial incongruence of the face (e.g., a White Caucasian transmitting an East Asian facial expression signal)? Would displays of other-culture facial expressions on ingroup faces increase motivation and facilitate learning of novel facial expression signals (Adams, Pauker, & Weisbuch, 2010; Young & Hugenberg, 2012)? Similarly, is the Other Race Effect (ORE)—characterized by faster race categorization of other-compared to same-race faces—(Caldara, Rossion, Bovet, & Hauert, 2004; Levin, 1996; Valentine & Endo, 1992) dampened by culturally incongruent facial expression signals (see also Michel, Rossion, Bülthoff, Hayward, & Vuong, this issue 2013)? Would pairing other-race faces with in-culture facial expressions diminish racial stereotyping effects (Bijlstra, Holland, & Wigboldus, 2010; Hugenberg & Bodenhausen, 2003)? On a related note, as illustrated earlier, the face provides a wealth of information about an individual's sex, age, race, emotional state, and even inferred social traits (e.g., dominance, attracti-venss, trustworthiness; see Oosterhof & Todorov, 2008), with some relying on similar or related face information. For example, social trait judgements (e.g., dominance) rely on information closely related to facial morphology (and therefore identity, gender, age, and race). In contrast, although emotion categorization is relatively independent from facial morphology—i.e., robust across different identities—facial expressions (e.g., anger) are correlated with specific social traits (e.g., dominance; Gill et al., 2012). Together, these highlight the potentially complex relationship between face information and social judgements, raising questions about which social categorizations occur earlier (or in parallel) due to similarities in the information underlying each judgement, and the consequences for subsequent social categorizations.

Finally, understanding emotion communication also has direct implications for the development of the digital economy. By refining knowledge of the facial expression signals that support universal recognition and those that convey culture-specific emotions, such questions will have broad impact in fields supporting the advancement of cyber-communication and cross-cultural communication interfaces (e.g., computer science, engineering, robotics).

Finally, although facial expressions may have biological origins, thousands of years of culture-specific social pressures, ideologies, and practices have likely shaped the basic facial expression signals that were once common to all. Extending similar empirical investigations to culturally valid facial expression signals and their decoding could provide valuable knowledge of the extent to which modern facial expressions have been shaped by the diverse geographical and sociocultural environmental pressures encountered by man in their evolutionary journey across the world some 60,000 or so years ago.

Bridging cultural differences in science

As illustrated above, modern knowledge of facial expression signalling and decoding is based on empirical investigations and theoretical developments from broad, traditionally distinct fields. For example, Darwin—a naturalist—observed the intimate link between signalling (i.e., production) and decoding (i.e., perception), proposing a coevolutionary account of facial expressions and first introducing recognition as a method to understanding facial expression signalling von Helmholtz—a physicist and physician—recognized the fundamental role of prior knowledge (i.e., culture-specific experiences and conceptual frameworks) in constructing visual experience. Together, these developments sparked parallel lines of investigation in the traditionally distinct but complementary fields of emotion research (e.g., Ekman et al., 1969) and visual and perceptual cognition (Smith et al., 2005), creating diverse cultures of scientific thinking. As with typical traditional research approaches, knowledge evolved in parallel fields with little integration (discussed in Brown & Seligman, 2009; Chiao, 2009; Ladd, Dediu, & Kinsella, 2008) resulting in some approaches akin to six blind men touching an elephant (Backstein, 1992). Now, as illustrated here with selected examples, new cross-disciplinary approaches, which also include broad fields of neuroscience, psychophysics, computer science, engineering, and genetics, have given rise to a modern culture of science that embraces and subsequently benefits from scientific diversity. Consequently, debate on the universality of facial expressions has reached a new juncture, with many exciting new research directions ahead.

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