Cultural Differences in the Decoding and Representation of Facial Expression Signals

Rachael E. Jack

Ph.D.

The University of Glasgow

The School of Psychology

September 2010

Summary

In this thesis, I will challenge one of the most fundamental assumptions of psychological science – the universality of facial expressions. I will do so by first reviewing the literature to reveal major flaws in the supporting arguments for universality. I will then present new data demonstrating how culture has shaped the decoding and transmission of facial expression signals. A summary of both sections are presented below.

Review of the Literature

To obtain a clear understanding of how the universality hypothesis developed, I will present the historical course of the emotion literature, reviewing relevant works supporting notions of a 'universal language of emotion.' Specifically, I will examine work on the *recognition* of facial expressions across cultures as it constitutes a main component of the evidence for universality. First, I will reveal that a number of 'seminal' works supporting the universality hypothesis are critically flawed, precluding them from further consideration. Secondly, by questioning the validity of the statistical criteria used to demonstrate 'universal recognition,' I will show that long-standing claims of universality are both misleading and unsubstantiated. On a related note, I will detail the creation of the 'universal' facial expression stimulus set (Facial Action Coding System[1]-FACS- coded facial expressions) to reveal that it is in fact a biased, culture-specific representation of Western facial expressions of emotion. The implications for future cross-cultural work are discussed in relation to the limited FACS-coded stimulus set.

Experimental Work

In reviewing the literature, I will reveal a latent phenomenon which has so far remained unexplained – the East Asian (EA) recognition deficit. Specifically, EA observers consistently perform significantly poorer when categorising certain 'universal' facial expressions compared

[1] The Facial Action Coding System (FACS) is a system designed to measure all visible facial behaviour as described by reference to functionally anatomical facial muscle movements called Action Units or AUs.

to Western Caucasian (WC) observers – a surprisingly neglected finding given the importance of emotion communication for human social interaction. To address this neglected issue, I examined both the decoding and transmission of facial expression signals in WC and EA observers.

Experiment 1: Cultural Decoding of 'Universal' Facial Expressions of Emotion

To examine the decoding of 'universal' facial expressions across cultures, I used eye tracking technology to record the eye movements of WC and EA observers while they categorised the 6 'universal' facial expressions of emotion. My behavioural results demonstrate the robustness of the phenomenon by replicating the EA recognition deficit (i.e., EA observers are significantly poorer at recognizing facial expressions of 'fear' and 'disgust'). Further inspection of the data also showed that EA observers systematically miscategorise 'fear' as 'surprise' and 'disgust' as 'anger.' Using spatio-temporal analyses of fixations, I will show that WC and EA observers use culture-specific fixation strategies to decode 'universal' facial expressions of emotion. Specifically, while WC observers distribute fixations across the face, sampling the eyes and mouth, EA observers persistently bias fixations towards the eyes and neglect critical features, especially for facial expressions eliciting significant confusion (i.e., 'fear,' 'disgust,' and 'anger').

My behavioural data showed that EA observers systematically miscategorise 'fear' as 'surprise' and 'disgust' as 'anger.' Analysis of my eye movement data also showed that EA observers repetitively sample information from the eye region during facial expression decoding, particularly for those eliciting significant behavioural confusions (i.e., 'fear,' 'disgust,' and 'anger'). To objectively examine whether the EA culture-specific fixation pattern could give rise to the reported behavioural confusions, I built a model observer that samples information from the face to categorise facial expressions. Using this model observer, I will show that the EA decoding strategy is inadequate to distinguish 'fear' from 'surprise' and 'disgust' from 'anger,' thus giving rise to the reported EA behavioural confusions. For the first time, I will reveal the origins of a latent phenomenon - the EA recognition deficit. I discuss the implications of culture-specific decoding strategies during facial expression categorization in light of current theories of cross-cultural emotion communication.

Experiment 2: Cultural Internal Representations of Facial Expressions of Emotion

In the previous two experiments, I presented data that questions the universality of facial expressions. As replicated in Experiment 1, WC and EA observers differ significantly in their recognition performance for certain 'universal' facial expressions. In Experiment 1, I showed culture-specific fixation patterns, demonstrating cultural differences in the predicted locations of diagnostic information. Together, these data predict cultural specificity in facial expression signals, supporting notions of cultural 'accents' and/or 'dialects.' To examine whether facial expression signals differ across cultures, I used a powerful reverse correlation (RC) technique to reveal the internal representations of the 6 'basic' facial expressions of emotion in WC and EA observers. Using complementary statistical image processing techniques to examine the signal properties of each internal representation, I will directly reveal cultural specificity in the representations of the 6 'basic' facial expressions of emotion. Specifically, I will show that while WC representations of facial expressions predominantly featured the eyebrows and mouth, EA representations were biased towards the eyes, as predicted by my eye movement data in Experiment 1. I will also show gaze avoidance as unique feature of the EA group.

In sum, this data shows clear cultural contrasts in facial expression signals by showing that culture shapes the internal representations of emotion.

Future Work

My review of the literature will show that pivotal concepts such as 'recognition' and 'universality' are currently flawed and have misled both the interpretation of empirical work the direction of theoretical developments. Here, I will examine each concept in turn and propose more accurate criteria with which to demonstrate ‘universal recognition’ in future studies. In doing so, I will also detail possible future studies designed to address current gaps in knowledge created by use of inappropriate criteria. On a related note, having questioned the validity of FACS-coded facial expressions as ‘universal’ facial expressions, I will highlight an area for empirical development – the creation of a culturally valid facial expression stimulus set – and detail future work required to address this question. Finally, I will discuss broader areas of interest (i.e., lexical structure of emotion) which could elevate current knowledge of cross-cultural facial expression recognition and emotion communication in the future.

Acknowledgements

I would like to take this opportunity to thank a number of people for their support during my Ph.D. First, I would like to thank my supervisor, Prof. Roberto Caldara for introducing me to a truly fascinating topic, generating a constant stream of creative ideas and engaging in enthusiastic discussion throughout; Dr. Monika Harvey and Prof. Stephany M. Biello for continued support, encouragement, and especially for their invaluable advice and guidance; Dr. Oliver G. B. Garrod for taking the time, patience and perseverance to make MATLAB fun; Prof. Simon Garrod for his valuable insights regarding data interpretation and application of methods; Dr. Guillaume A. Rousselet for never turning me away from his office door when I had questions about statistics or biology, and always furnishing me with knowledge when he had the answer and books when he didn't; Dr. Sébastien Miellet for his limitless hard work and dedication to the lab, and Prof. Philippe G. Schyns for unending patience, guidance, knowledge and above all, priceless opportunities. Finally, I would like to thank both The Economic and Social Research Council and Medical Research Council (ESRC/MRC-060-25-0010; PTA-031-2006-00192) for providing financial support for my Ph.D. research.

Table of Contents

It is noted here that use of inverted commas are used to refer to specific emotion response categories (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger,' 'sad'), items in a figure legend (e.g., 'WC,' 'AG,' or 'best fit'), to indicate irony (e.g., 'universal,' 'instinctual' or 'basic') or to distance the author from terms coined by others (e.g., cultural 'accents,' or 'display rules').

List of Figures

1. General Introduction

Facial expressions of emotion have long been a source of wonderment and fascination amongst philosophers, anthropologists, psychologists, physicians and more recently engineers, physicists and computer scientists. Central to all human social interaction is the mutual understanding of emotion, achieved primarily by the exchange of a set of potent social signals – facial expressions of emotion. Given that various scientific fields have contributed to current knowledge of facial expressions, it is useful to track the historical course of emotion literature to obtain a clear understanding of the theoretical and empirical positions of today.

1.1 The Anatomy of Facial Expressions – a Gift from God

Early research on facial expressions focused primarily on describing the anatomical mechanisms subserving the production of facial expressions. The noted anatomist, Sir Charles Bell, was amongst the first to extensively examine the musculature of the face, producing detailed illustrations and cataloging the involvement of specific muscles in the expression of different emotions(e.g., Bell, 1844; see also Henle, 1868). Consequently, in his celebrated works Guillaume Duchenne stimulated specific combinations of muscles via faradic (non-convulsive) shocks delivered to the face to capture 'true' facial expressions on photographic film for the first time (Duchenne, 1862-1990). While not primarily concerned with the origins of facial expressions, Bell and Duchenne proposed that God had bestowed man with facial muscles solely for the purposes of emotion communication, which were to be used in accordance with the God-given language of facial expressions. Although quite inadvertently, their views on the origins of facial expressions of emotion stirred doubt in the mind of one the most influential scientists – Charles Darwin.

1.2 The Origins of Facial Expressions – Darwin's Legacy

Unconvinced that facial expressions are 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, 1999/1872). Here, he directly asked the question 'why?' for the first time. That is, why do facial expressions take on their distinctive form? For example, why is the emotion 'disgust' accompanied by a raised top lip, wrinkled nose and narrowing of the eyes, whereas 'fear' is associated with wide opened eyes, raised eyebrows and flared nostrils (see Figure 1.1, Panel A for an example)? Why should these apparently arbitrary facial patterns accompany different internal emotions?

1.2.1 Facial Expressions as Sensory Regulators

In observing that primates of human ancestry possessed facial muscles and facial expressions similar to those of humans (see also Andrew, 1963), Darwin surmised that facial expressions may have developed to perform some adaptive function when humans "existed in a much lower and animal-like condition" (Darwin, 1999/1872, pg 19). For example, all facial expressions involve the contraction of specific facial muscles, which can either enhance or diminish sensory input. Consider the facial expression 'disgust,' which is characterized by a raised top lip, wrinkled nose, narrowing of the eyes and lowered eyebrows (see Figure 1.1, Panel B for an example).

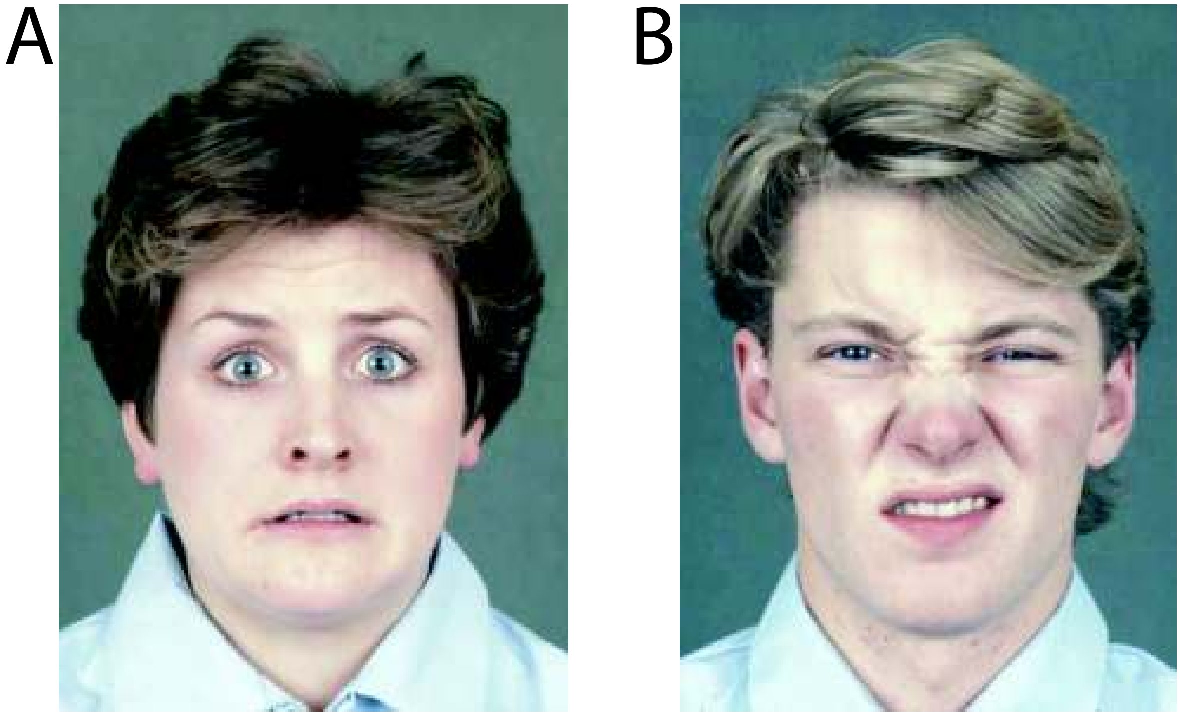

Figure 1.1 Examples of the Facial Expressions Typically Associated with the Internal Emotions of 'fear' and 'disgust.' Panel A: Displays a showing an example of the facial expression typically associated with the internal emotion 'fear.' Note the characteristic wide opened eyes, raised eyebrows, wrinkles brow, opened mouth and flared nostrils. Panel B: The face displayed shows 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. I selected both examples from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE) stimulus set (Matsumoto & Ekman, 1988).

In Panel A above, the face image depicts the external facial expression associated with the internal emotion 'fear.' Note the characteristic wide opened eyes, raised eyebrows, wrinkles brow, opened mouth and flared nostrils. The face image in Panel B shows an example of the facial expression representing the internal emotion 'disgust.' Note the characteristic raised top lip, wrinkled nose and narrowing of the eyes. Both facial expression examples are sourced from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE) stimulus set (Matsumoto & Ekman, 1988).

Together, these specific patterns of muscular contractions perform a number of useful functions – while raising the top lip and wrinkling the nose blocks the nasal passage, thus reducing olfactory stimulation, narrowing the eyes and lowering the brow not only offers protection to the eye but also diminishes the field of view and thus visual stimulation (Andrew, 1963; Susskind, et al., 2008). In addition, the facial expression of 'disgust' may also include the protrusion of the tongue or gaping, which facilitates the expulsion of any unpleasant items from the mouth (Rozin & Fallon, 1987). Under circumstances of potential contamination (e.g., close proximity to a decomposing body dispersing pathogens), the facial expression of 'disgust' is indeed an effective strategy for rejecting noxious contaminants (Rozin & Fallon, 1987; Rozin, Lowery, & Ebert, 1994) as it protects the regions most vulnerable to the entry of pathogens (i.e., eyes, nose and mouth).

Similarly, the facial expression typically associated with the emotion 'fear' also facilitates adaptive action, but by providing quite the opposite sensory experience. As shown in Figure 1.1, Panel A, the characteristic facial expression of 'fear' involves raised eyebrows, wide opened eyes and flared nostrils. In this case, raising the eyebrows and opening the eyes wide increases the visual field, thus enhancing visual input, while flaring the nostrils increases the capacity of the nasal passage and thus nasal inspiration (Andrew, 1963; Susskind, et al., 2008). In circumstances where a threat is in close proximity, the facial expression of 'fear' facilitates adaptive action (i.e., escape) by increasing visual information (e.g., identifying escape route options) and the input of oxygen (e.g., optimizing muscle function). Similar examination of each of the other 'basic' facial expressions (i.e., 'happy,' 'surprise,' 'anger' and 'sad') has revealed a plausible biological function for each (Andrew, 1963; Susskind, et al., 2008), thus answering the original question, "why do facial expressions take on their distinctive form?"

1.2.2 Facial Expressions as a Physiological Reaction

With strong support for the biological and evolutionary origins of facial expressions, facial expressions were largely considered an innate, reflexive behaviour, appearing in conjunction with various other physiological responses during particular emotional states.

Conceiving of facial expressions more as a physiological response, rather than a social signal *per se*, various studies catalogued the behavioural and physiological responses elicited during emotional arousal. For example, in his startlingly unethical study, *Studies of Emotional Reactions: General Behaviour and Facial Expressions,* Landis (Landis, 1924) examined modulations in the blood pressure, heart rate and facial expressions of participants during emotional arousal elicited by external provocation (e.g., detonating fire crackers under naïve participants, forcibly instructing the decapitation of a rat). By capturing facial expressions with a camera (see also Feleky 1916), Landis was able to capture and systematically described facial responses with reference to the solicitation of facial certain muscles. Cannon also famously described and documented a wide variety of physiological change associated with emotional arousal (Cannon, 1915). More recent research continues to demonstrate the relevance of physiological reaction during emotional experience. For example, when confronted with facial expressions, observers show distinct neurophysiological (Philippe G. Schyns, Petro, & Smith, 2009), autonomic and facial reactions (Dimberg, 1982) even during subconscious presentation of stimuli (Dimberg, Thunberg, & Elmehed, 2000).

1.2.3 Facial Expressions as Social Signals

If facial expressions originally served to regulate sensory exposure as a reflexive action, how then did facial expressions evolve as social signals? To answer this question, it is important to consider the inherent qualities of facial expressions that give them a natural advantage for communicating information.

(a) Signaling Qualities of Facial Expressions

By virtue of their specific biological function and pattern of muscular activation, each facial expression constitutes a different and complex visual pattern (e.g., note in Figure 1.1 the visual dissimilarity between ‘fear’ in Panel A and ‘disgust’ in Panel B). Each complex visual pattern is composed of ‘basic’ components of information – spatial frequencies[2] of varying contrasts and orientations. Importantly, the human visual brain is particularly sensitive to these features. For example, populations of cells in V1 (primary visual cortex) are maximally sensitive to specific spatial frequencies (De Valois, De Valois, & Yund, 1979; Maffei & Fiorentini, 1973), therefore acting as decoders to decompose incoming images into spatial frequency (see Sowden & Schyns, 2006). Given the sensitivity of the brain to these features, each complex pattern (i.e., facial expression) is easily discriminated by the human visual system (e.g., Philippe G. Schyns, et al., 2009) and is therefore recognizable – an essential feature of any effective signal.

Secondly, the ‘basic’ components (i.e., different spatial frequencies) of facial expressions perform another useful function – transmitting information over different distances. While lower spatial frequency features (i.e., the large-scale smiling mouth in ‘happy’) are visible across a wide range of viewing distances, higher spatial frequency information (i.e., the fine-scale wrinkles on the nose in ‘disgust’) are only visible at closer viewing distances. Depending on the function of the facial expression, it is likely that the features relevant for accurate recognition (i.e., 'diagnostic recognition.' See M. L. Smith, Cottrell, Gosselin, & Schyns, 2005) evolved to posses certain visual characteristics that enable the transmission of information over longer or shorter viewing distances. For example, the facial expression of ‘disgust’ indicates the presence of a proximal threat (e.g., decomposing carcass dispersing pathogens with limited trajectory), thus requiring visibility over short rather than long viewing distances (i.e., at longer distances, the threat would pose no risk to the observer). Indeed, accurate recognition of ‘disgust’ facial expressions relies on the fine-scale wrinkles around the nose, thus requiring a proximal rather than distal viewing distance (F. W. Smith & Schyns, 2009). Thus, while originally serving to regulate sensory exposure, facial expression signals are likely to have co-evolved with and the corresponding neural sensitivities of the brain in response to additional environmental pressures

[2] Here, spatial frequency is measured in cycles per degree (CPD) of visual angle.

(e.g., effective group communication of threat), creating an optimal system of signaling and decoding (Philippe G. Schyns, et al., 2009).

(b) Informational Content of Facial Expressions

As mentioned above, facial expressions have an inherent ability to communicate information between humans by virtue of their distinctive appearance and visibility by the human visual system. Although primarily serving to modulate sensory experience, Darwin surmised that through habit and association, facial expressions would be elicited during emotional arousal even though its functional role may not be necessary. As a result, rather than simply reflecting the conditions of the environment *per se*, facial expression would reliably indicate internal emotional states, howsoever elicited. Thus, while originally designed to benefit the expresser, facial expressions also provide a rich source of information for the observer – another trait that natural selection is likely to have favoured. At this point, it is worthwhile considering the various types of information facial expression signals provide. Here, I will detail 3 types of information facial expressions provide – environmental conditions, behavioural intentions of the expresser, and appropriate behavioural response. To illustrate the point, I will use the 'negative' facial expressions (i.e., 'fear,' 'anger,' 'disgust' and 'sad') as they provide excellent examples of the rich informational content of facial expression signals.

c) Environmental Conditions

As mentioned previously, facial expressions can reflect information about the current conditions of the environment. Consider each of the 'negative' facial expressions – 'fear,' 'anger,' 'disgust' and 'sad.' While all conveying negative information (i.e., presence of some kind of threat), each provides information about the nature of the threat. For example, 'fear' conveys that the threat (e.g., predatory tiger) is in close proximity and immediate, whereas 'disgust' reflects that while a threat is present (e.g., decomposing body dispersing pathogens), it is relatively less mobile. 'Anger,' on the other hand reveals the precise source of the proximal threat (i.e., the expresser), whereas 'sad' shows that the threat is likely to be distal and/or non-life threatening (e.g., the death of a relative).

d) Behavioural Intentions of the Expresser

Similarly, facial expressions can also provide predictive information about the likely behavioural intentions of the expresser, adding more information about the environmental conditions. For example, a facial expression of 'fear' indicates that the expresser is likely to adopt a flight, fight or freeze response to the immediate threat, whereas a facial expression of 'disgust' shows that the expresser will avoid the threat but do so with less immediacy. In contrast, 'anger' shows that the expresser intends to attack those who do not heed their warning, while 'sad' indicates that the expresser is unthreatening, vulnerable and will perhaps seek consolation.

e) Appropriate Behavioural Response

In all instances mentioned above, each facial expression provides different information about the behavioural intentions of the expresser and/or the current environmental conditions, which then allows observers to choose an appropriate behavioural response. For example, a facial expression of 'fear' indicates that a quick flight, fight or freeze response is required for survival, whereas 'disgust' shows that a less immediate and energy consuming avoidance response is required. In both cases, the observer is likely to mirror the behaviour of the expresser[3]. In contrast, 'anger' indicates that the observer should quickly avoid the expresser if they wish to avoid a harmful attack, whereas a facial expression of 'sad' shows that the observer should approach to offer consolation. In these cases, the observer's behavioural response is

[3] Here, I have used an example that reflects visceral (e.g., any entity dispersing pathogens), rather than moral (e.g., any violation of a moral or ethical code) 'disgust.' While both visceral and moral 'disgust' are represented by similar facial expressions (see Rozin, et al., 1994 for modulations in 'Disgust' facial expressions), the consequences for the observer's behaviour and cognitions are likely to differ. Consider a situation in which the observer is the source of moral 'disgust.' Here, the 'disgust' facial expression represents a rejection of the observer due to their distasteful acts. In response, the observer is less likely to mirror the actions of the expresser as in the case of visceral 'disgust' , but is instead more likely to choose an avoidance behaviour. The avoidance response can be enhanced if desired by blending 'disgust' with 'anger,' (which moral and ethical violations tend to arouse) commonly referred to as 'contempt.'

directly related to the likely intentions of the expresser rather than any other third-party external threat or stimulus.

With such a large and various amount of information available in a single signal, coupled with inherent visual signalling qualities, facial expressions are indeed a prime candidate to evolve as strong social signals. Given the highly adaptive role of facial expressions and their ability to increase the chances of survival (e.g., by rejecting noxious contaminants), any trait facilitating the production and recognition of facial expressions would be passed on to the next generation by natural 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. Darwin's theory of the evolutionary development of facial expressions is further supported by cross-species similarity in facial expressions (e.g., Andrew, 1963; Vick, Waller, Parr, Smith Pasqualini, & Bard, 2007), which demonstrates a link between human facial expressions and primitive behaviours. Furthermore, neonates and infants have been shown to produce discernable facial expressions such as 'disgust' (Rozin & Fallon, 1987), 'surprise' and 'happy' (e.g., Hiatt, Campos, & Emde, 1979), supporting the view that facial expressions are innate and not entirely socially learned.

1.3 The Influence of Culture on Facial Expressions – Anthropological Observations from Across the World

With the strong biological and evolutionary origins of facial expressions, notions of universality became a widespread working assumption with little or no cross-cultural research conducted or 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 as a potential source of variation since facial expression were assumed to be universal on the basis of their evolutionary origins. Thus, facial expressions were largely considered to be the biologically hard-wired 'universal language of emotion.'

Yet, with increasing knowledge of human behaviour within different cultures, notions of universality and the idea of 'basic human nature' became a source of fervent debate. From the Amazon to Zanzibar, anthropological observations detailed marked and surprising cultural differences in behaviours widely assumed to be innate. One of the most striking differences reported was in the use of gestures widely believed to be 'natural' such as pointing, conveying 'yes' and 'no' and greeting customs. For example, nodding the head to indicate 'yes' and shaking the head laterally to signify 'no' was largely accepted as an instinctual, biological and therefore universal human behaviour (see Holt, 1931). However, anthropological observations provide a multitude of examples, which contradicted this view. For example, while the Bengalese rock their heads from shoulder to shoulder to indicate agreement, in Borneo raising the eyebrows is used to achieve the same function and in Northern Japan, hand rather than head gestures are used to convey 'yes' and 'no' (see also Labarre, 1947; D. Morris, 1979). With such diversity in human behaviour considered to be 'natural,' these observations invited caution in assuming that *any* human behaviour is biologically hard-wired and universal. Rather, these examples highlight that many social behaviours are learned and therefore determined by culture.

Given that facial expressions, like gestures, are used primarily to convey information during social interaction, many reasonably considered that culture could shape facial expression signals in the same way. Indeed, numerous colourful descriptions of differences in the expression of emotion across cultures demonstrate the immense power of culture in shaping these so-called biologically hard-wired behaviours. One of the most cogent examples of culture-specific displays of emotional expression is documented by the explorer and historian, John Turnbull who observed a particularly unusual greeting ritual in Tahiti. He reports that after a long separation, the Tahitians 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, and this they will repeat, till they become clotted with blood and gore"* (Turnbull, 1813, pg. 301-302). Left with only complete incomprehension as to the origins or symbolic relevance of this ritual, he could only conclude that such behaviour intended to *"…express the excess of their joy"* (pg. 302). While this is of course a strikingly odd example of emotional expression (at least to non-Tahitians at that time) used to illustrate the point, it is by no means an isolated finding. Many other examples of culture-specific emotional expressions have been reported, causing as much confusion as that experienced by John Turnbull on the shores of Tahiti. For example, the Japanese smile is used not simply to convey joy, but is used primarily as a social courtesy to mask external displays of negative emotions such as fear or sad, much to the confusion and distress of Westerner observers (see Hearn, 1894 for examples). Similarly, laughter is used to express a variety of other incongruent emotions such as surprise, embarrassment and even discomfort in certain areas of Africa (Gorer, 1935). The Utku (Utkuhikhalingmiut) Eskimos of Northwest Canada consider outward expressions of anger to be childish and external manifestations of the internal state are typically masked with a neutral expression (Briggs, 1970). In contrast, an American Indian tribe, the Kiowa Tribe of Oklahoma encourages the enthusiastic outward expression of emotion during specific events, even when the internal emotion is absent. For example, LaBarre (1947) describes Mary Buffalo, a Kiowa member, at the funeral of her brother whom she has not seen in a long time and was not particularly close – *"...she wept in a frenzy, tore her hair, scratched her cheeks, and even tried to jump into the grave…"* (Labarre, 1947, page 55). After observing her cheerful and calm behaviour immediately afterwards, LaBarre concludes that he has witnessed Mary Buffalo acting as any decent Kiowa woman would do at a funeral.

With such diversity in the expression of emotions across cultures, it was argued that while facial expressions may have a biological basis, culture so heavily influences their use that facial expressions no longer necessarily convey the same meaning across all cultures. Thus, many anthropologists rejected notions of a 'universal language of emotion,' stating that facial expressions are socially learned and not instinctual as initially believed. With such apparently contradictory accounts of the nature of facial expressions (i.e., biological vs. cultural basis), and some even arguing that facial expressions are entirely socially learned (Klineberg, 1940; Labarre, 1947; Mead, 1975), opinion was largely divided, sparking controversy in the field.

1.4 Fusing Biology and Culture - A 'Neuro-Cultural' Theory of Facial Expressions of Emotion

In light of to the apparently contradictory nature-nurture components of facial expressions and ensuing debate, theoretical developments (Ekman, 1972; Tomkins, 1962, 1963; Tomkins & McCarter, 1964) emerged to account for the interactive influences of biology and culture on the production of facial expressions. Here, I will describe the 'neuro-cultural' theory of facial expressions developed by Paul Ekman (Ekman, 1972), which built on an earlier theory introduced by Tomkins (Tomkins, 1962, 1963). The 'neuro-cultural' theory of facial expressions is composed of a series of stages where either biology or cultural factors influence the production of facial expressions. Although the theory includes descriptions of cultural differences in the elicitors of emotion (e.g., spouse taking a secondary wife) and the consequences of displaying certain facial expressions (e.g., feeling guilty in response to initial emotional state), I will detail two stages most relevant to this thesis – the biological starting point of facial expression production (i.e., the innate Facial Affect Programme) and the influence of culture-specific norms on subsequent external displays of facial expressions (i.e., display rules).

1.4.1 The Facial Affect Programme

Largely influenced by the evolutionary origins of facial expressions, the 'neuro-cultural' framework proposes that facial expressions are generated by an innate, sub-cortical Facial Affect Programme, (Tomkins, 1962, 1963), which originally served as an adaptive mechanism to regulate sensory exposure. Specifically, each primary[4] emotion (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad') is thought to be accompanied by a distinct pattern of neural impulses sent to specific facial muscles, thus producing a characteristic facial expression. At this stage of production, a facial expression is largely considered to be one of the many reflexive, physiological responses produced during emotional arousal, such as increased pulse rate, perspiration and so forth. Given that the proposed Facial Affect Programme is a primitive and innate system, the distinct patterns of neural impulses sent to the facial muscles would be the same across all humans, regardless of culture. In other words, the Facial Affect Programme is a universal human feature, generating emotion-specific neural impulses to the facial muscles.

1.4.2 Display rules

The next stage of facial expression production details the operation of culture-specific display rules, which can interfere with the full expression of so-called 'instinctual' facial expressions of emotion (i.e., those generated by the Facial Affect Programme). display rules are described as socially learned management techniques, which govern when, how and to whom facial expressions ought to be displayed. For example, although a Western male feels 'sad' during a funeral, cultural norms dictate that he should refrain from displaying any signs of 'sad' in public and instead maintain a more neutral, emotionless expression. Here, he would adhere to the cultural 'display rule' by diminishing any facial signs of 'sad' and replacing the 'instinctual' facial expression (i.e., 'sad') with a more 'neutral' one. Similarly, the same scenario in Japan would result in the Japanese male masking internal feeling of 'sad' but by displaying a 'happy' facial expression in order to avoid making others feel uncomfortable by his 'sad' and preserving group harmony.

[4] Here, 'primary' emotions are considered to be irreducible and are therefore alternatively referred to as 'basic' emotions. Similar to primary colours, 'primary' emotions can be combined to produce 'blended' emotions (Ekman, 1972). For example, smugness can be described as a combination of happiness and 'anger' , whereas jealousy comprises 'anger' and 'sad' ness.

As illustrated in the examples above, the operation of display rules elicits a secondary modulation in the facial muscles to diminish, enhance, mask or replace the initial pattern of neural impulses (i.e., the instinctual facial expression generated by the Facial Affect Programme) as appropriate. As a result, the facial expression produced may not necessarily reflect the emotion experienced (e.g., displaying a 'happy' facial expression when feeling 'sad'). Depending on the intensity of the internal emotion, diminishing, enhancing, masking or replacing the 'instinctual' facial expression can be achieved with varying degrees of success. Consider that the Western male attending the funeral is overcome with grief and 'sad.' While the social norm of "putting on a brave face" has been ingrained since childhood, the intensity of the emotion experienced may be too great, and any attempt to conceal the 'instinctual' facial expression of 'sad' may be less than successful. As a result, some facial signs of the emotion experienced would 'leak,' producing a facial expression that contains recognizable or contorted aspects of the instinctual facial expression. However, with some display rules learned from an early age (e.g., to smile when greeting people), the interference process could become habitual, requiring less cognitive processing compared to those less frequency used (e.g., smiling when losing a game) enabling quick and precise operation under most circumstances. Thus, culture-specific display rules *can* interfere with the external display of 'instinctual' facial expressions of emotion, resulting in cultural differences in the facial expressions displayed during the same emotional experience (e.g., 'happy' or 'neutral' facial expression while feeling 'sad').

Here, the 'neuro-cultural' theory details the contribution of both biological (i.e., universal) and cultural factors in the production of facial expressions to account for the reported cultural differences in the display of facial expressions. They argue that it is the innate Facial Affect Programme and emotion-specific neural impulses that are universal and that the reported cultural differences in facial expressions are simply a reflection of socially learned, culture-specific 'display rules.' That is, in the absence of any culture-specific display rules, all humans would display the same 'instinctual' facial expressions as generated by the Facial Affect Programme. Yet, while providing a plausible theoretical account of facial expressions and their modulating factors, in the absence of any empirical work, the universality debate remained unresolved.

1.5 Empirical Evidence from Cross-Cultural Recognition Studies

With increasing debate on whether facial expressions are innate (and therefore universal) or socially learned, a landslide of empirical research dedicated to unraveling the nature-nurture debate ensued. The rest, they say, is history, but it is imperative that we now return to this historical turning point, which shaped the future of emotion research and the knowledge of today.

It was argued that the reported cultural differences in facial expressions could be due to the operation of culture specific display rules and/or the observations of facial expressions used during social interaction (i.e., gestural facial expressions) rather than those associated with the emotion-specific pattern of neural impulses delivered to the facial muscles (i.e., 'instinctual' facial expressions) as proposed in the 'neuro-cultural' framework. In distinguishing between these two types of facial expressions, current studies aimed to demonstrate the presence of 'instinctual' facial expressions in support of the university hypothesis. Rather than attempting to elicit specific emotions and record the subsequent uninhibited facial expressions (e.g., Landis, 1924), it was reasoned that recognition studies could be used to show pan cultural elements of facial expressions. The rationale behind using recognition studies was that while culture could modulate the production of facial expressions via display rules, the same 'instinctual' facial expressions would still occur in every culture. For example, on the one hand, where display rules are not yet learned (e.g., in early childhood) or fail to operate (e.g., when emotional experience is overwhelming) 'instinctual' facial expressions would be displayed. As a result, all 'instinctual' facial expressions would be recognizable by all humans, regardless of culture. On the other hand, if facial expressions were entirely socially learned and culture-specific, the unique facial expressions generated in one culture would be completely incomprehensible to those in another culture, resulting in a complete lack of agreement about their meaning.

With this rationale, scholars such as Ekman and Izard conducted a series of cross-cultural recognition studies involving observers in various distinct cultures. By presenting observers in the USA, Brazil, Japan, New Guinea and Borneo with facial expressions posed by USA posers, the studies showed that all observer groups could recognize all 6 'basic' facial expressions of emotion (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger,' and 'sad') at above chance performance (Ekman, Sorenson, & Friesen, 1969). With findings replicated across various other distinct cultures (e.g., Ekman, 1972; Izard, 1971) the authors concluded that facial expressions are the 'universal language of emotion.'

1.6 Challenging Notions of a 'Universal Language of Emotion' - A Closer Look at the Data

Although work from scholars such as Ekman and Izard are cited as irrefutable evidence for the universality of facial expressions, the criteria used to demonstrate 'universal recognition' is flawed, subsequently masking notable cross-cultural differences in the recognition of facial expressions. To reveal these flaws, I will examine the main studies that have reported 'universal recognition' of facial expressions and discuss the implications of their results. Before I do so, it is important to first highlight the so-called seminal works that cannot be included for further consideration due to failure to meet basic research criteria. Each study is detailed below, accompanied by the reasons for their exclusion from this thesis.

1.6.1 Empirical Studies Excluded from Further Consideration

1. *Constants Across Cultures in the Face and Emotion*. (Ekman & Friesen, 1971).

In this study, the authors showed that both WC and South Fore of New Guinea observers could accurately recognize facial expressions posed by members of the other cultural group. While cited in a large number of published papers (Ekman, 1972; Ekman, et al., 1987; Ekman, Rolls, Perrett, & Ellis, 1992) in support of the universality hypothesis, this study suffers from two noteworthy deficits. First, the South Fore performed a 3 Alternative Forced Choice (AFC) categorization task whereby observers indicated which of 3 facial expressions best represented the emotion conveyed by a story read to them. With such a limited design of only 3 choices, performance most closely reflects a simple discrimination task (A-not-A) rather than recognition *per se.* Furthermore, observers were presented with an uneven distribution of emotion combination conditions (e.g., facial expressions of 'disgust' were only paired with 'surprise' and 'sad' while 'happy' was paired with all other facial expressions), which can invite spurious inconsistencies in the data. Secondly, while being mentioned in passing in the above published paper (Ekman & Friesen, 1971), data detailing a task where WC observers recognized posed facial expressions of the South Fore did not undergo peer review, appearing only as conference proceedings (Ekman, 1968).

2(a) *Facial Behaviour and Stress in Two Cultures* (Ekman, Lazarus, Opton, Friesen, & Averill, 1970).

2(b) *Cultural Differences in Facial Expressions in a Social Situation: An Experimental Test of the Concept of Display Rules* (Friesen, 1972).

In above 2 studies, the authors examined the influence of culture-specific display rules on the production of facial expressions by recording WC and EA participants while watching stressful films either alone or in company (i.e., when an experimenter was present). While both WC and EA participants freely expressed emotion when alone, only EA participants tended to mask negative facial expressions (e.g., 'disgust') when in company. Although cited in a number of published papers (e.g., Ekman & Friesen, 1971; Ekman, et al., 1992) supporting the universality of facial expressions and the operation of culture-specific display rules on facial expression production, the work of (2a) lacks peer review publication, with the work of (2b) constituting an unpublished doctoral dissertation.

1.6.2 Criteria Used to Demonstrate 'Universal Recognition' is Flawed

Since the inception of cross-cultural facial expression recognition studies, 6 'basic' facial expressions of emotion are reported to be universally recognized (e.g., Ekman, et al., 1969). At this juncture, it is important to understand how the literature has so far defined 'universal recognition.' As summarized by Matsumoto, "…universal recognition [is] demonstrated by two criteria: first, that [recognition accuracy is] significantly greater than chance; and second, that the percentage [is] greater than an arbitrary level, usually 70%, across all cultures" (Matsumoto, 1992, pg. 72). Yet, these criteria are critically flawed for two reasons.

a) Insensitive Criteria Generates Type II errors

These criteria are misleading because they mask the systematic cultural differences reported in all such cross-cultural recognition studies (Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, Blais, Scheepers, Schyns, & Caldara, 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi, et al., 2005). For example, while WC observers recognize all 6 'basic' facial expressions with high accuracy (typically >85% for all expressions), other cultural groups perform significantly poorer for certain facial expressions such as 'disgust,' 'anger' and 'fear' (Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989). Figure 1.2 below illustrates the variation in facial expression recognition performance across cultures using data extracted from various well-known cross-cultural facial expression recognition studies (Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989).

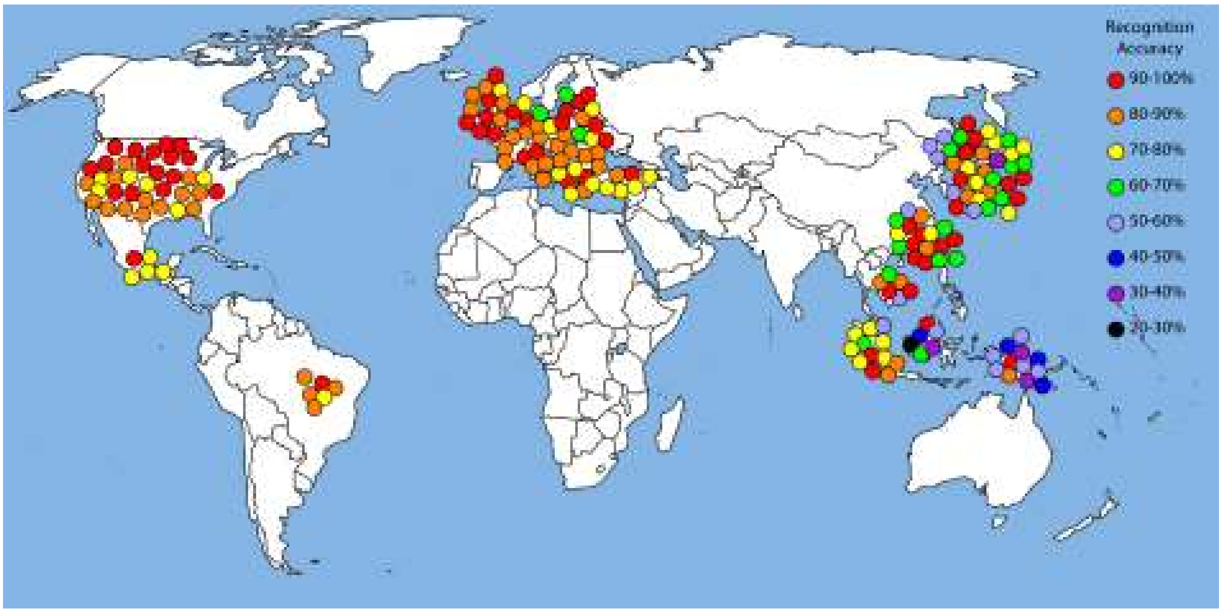

Figure 1.2 Mean Recognition Accuracy of Facial Expressions of Emotion Across Cultures. Colour-coded circles presented on geographical regions of the world map represent the mean recognition accuracy (%) of observers from that geographical region when categorising facial expressions of emotion. Each colour-coded circle corresponds to represents one of the 6 facial expressions (not indicated) where recognition accuracy is indicated by a different colour (see key on the upper right of the figure, labelled 'Recognition Accuracy'). For example, recognition accuracy for facial expressions of emotion in North America (left most cluster of coloured circles) ranges between 100% (red) and 70% (yellow) accuracy whereas in New Guinea (right most and lower cluster of coloured circles), accuracy ranges from 100% (red) to 30% (purple). The data points (i.e., colour-coded circles) presented here are extracted from various well-known studies (Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989).

b) Above Chance Performance Does Not Reflect 'Normal' Human Recognition

Defining that 'recognition' is demonstrated by above chance performance (i.e., 14%-16% accuracy, depending on a 6AFC or 7AFC task) is completely inappropriate as it does not accurately reflect 'normal' human recognition (e.g., the clinical definition of 'normal' human recognition would be at least 75% accuracy; see Duchaine & Nakayama, 2006). Indeed, it can easily be argued that many cultures failed to even achieve recognition at all (i.e., note in Figure 1.2 the number of yellow, green, blue(s), purple and even black circles in the Eastern countries). It is also important to point out that although finding clear variation in recognition accuracy across cultures (from 100% to 30%), the vast majority of studies apparently altered the 'arbitrary level' of performance as desired in order to conclude that facial expressions are universally recognized (Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989).

Clearly, such criteria can never be used to demonstrate universal recognition. Rather, criteria demonstrating universal recognition would reflect that a) recognition has been achieved by all observer groups and that b) performance is comparable (i.e., universal) across all observer groups. When more appropriate criteria are applied to the existing data, facial expressions are *not* universally recognized. I will further discuss the development of improved criteria in the *General Conclusion*.

1.7 Theoretical Accounts of Cultural Variation in Recognition Performance

As described above, studies showing consistent and significant cultural differences in the recognition of facial expressions are indeed numerous, dating back to some of the first cross-cultural studies (e.g., Ekman, et al., 1969). Although Ekman previously argued that cultural differences in recognition performance may be due to methodological errors rather than any real cultural difference *per se* (Ekman, 1994), several reviews of the literature (Elfenbein & N. Ambady, 2002; Russell, 1994) have generated discussion and the development of theoretical accounts (Elfenbein & N. Ambady, 2002; Elfenbein, Beaupre, Levesque, & Hess, 2007; Matsumoto & Ekman, 1989). Primarily, the seminal works of Russell (Russell, 1994) created controversy and debate within the field, not only by highlighting a number of methodological flaws in the literature, but also by presenting a comprehensive account of emotion as a complex social concept, which is malleable to the influences of culture. For example, noting that facial expressions are but one of the many dimensions of emotional experience, Russell discusses cultural differences in the conceptual nature of emotion. For example, events eliciting the emotion 'anger' are likely to differ across cultures due to the influence of social norms and rules (e.g., husband taking another partner or child refusing to enter marriage at the age of 10 years old). In turn, the experience of ‘anger’ may differ across cultures due to underlying concept of the emotion. For example, while some cultures may experience ‘anger’ broadly as high arousal displeasure, others may include dimensions of frustration, threat of violence against others and determination. Experience of an emotion itself can also trigger other emotions, depending on the culture. For example, feelings of ‘anger’ in Eastern culture are typically associated with shame and guilt, while Westerners do not experience a secondary emotion in response to the first. In sum, Russell presents a comprehensive view of emotion and emotional experience as a partly social construct that is therefore influenced by the underlying ideologies of society. As a result, he highlights that while emotion has shared biological aspects, culture plays an important role in understanding human emotional experience and emotion communication.

In explaining cultural differences in the recognition of facial expressions, discussion and theoretical developments have considered two sources of cultural variation – cultural differences in the *transmission* of facial expressions and cultural differences in the *decoding* of facial expression signals. Here, I will detail both accounts.

First, it is important to consider how culture could modulate the biologically based skills of facial expression transmission and decoding. Examination of the moral, social and political ideologies of diverse cultures shows that each embraces a specific conceptual framework of beliefs, knowledge and values. Specifically, while Western cultures promote individualistic behaviours and attitudes, Eastern cultures value collectivist practices (e.g., Niedenthal, Krauth-Gruber, & Ric, 2006), which shape thought and action (see Nisbett & Masuda, 2003 for a review).

1.7.1 Transmission of Facial Expression Signals

With this in mind, it has been argued that Easterners may use culture-specific display rules, to actively suppress the public display of certain negative emotions in order to preserve group harmony (Ekman, 1972; Ekman & Friesen, 1969; Ekman, et al., 1969). By systematically diminishing the frequency of transmission of certain negative facial expressions, observer experience in recognizing negative expressions could decrease, thus giving rise to the reported EA recognition deficit (e.g., Biehl, et al., 1997; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi, et al., 2005).

It has also been proposed that the 'basic' facial expressions could be subject to culture-specific 'dialects' (Elfenbein, Beaupré, Levesque, & Hess, 2007; Tomkins & McCarter, 1964) or 'accents' (Marsh, Elfenbein, & Ambady, 2003), resulting in perceptible variations in the 'basic' facial expressions. As a result, out-group members would be put at a disadvantage when decoding less familiar facial expression 'accents' (Elfenbein & Ambady, 2003), giving rise to the proposed in-group advantage (Elfenbein & N. Ambady, 2002). Indeed, in a clever study, Marsh et al. (2003) showed that even standardized (FACS-coded) facial expressions contain cultural 'accents,' which reliably betray the poser's nationality(Marsh, et al., 2003). Here, observers of Japanese nationality were asked to judge the nationality of Japanese nationals and USA born Japanese posers. When the posers displayed a 'neutral' facial expression, the observers could not accurately judge the nationality of the posers. However, when the posers displayed a facial expression (i.e., 'disgust,' 'fear,' 'sad,' or 'surprise'), observers were significantly better at judging their nationality. While the results of this study demonstrate that these 'universal' facial expressions contain culture-specific information, it is not yet known which specific face information this relates to. Further work is needed to clarify which face information of so-called 'universal' FACS-coded facial expressions are in fact culture specific and/or diagnostic of nationality.

1.7.2 Decoding of Facial Expression Signals

Similarly, using the same rationale of culture-specific social priorities, it has been proposed that Easterners may use 'decoding rules' to interpret facial signals. In this case, 'decoding rules' actively discourage the explicit acknowledgement of negative emotions to avoid social disruption by (Buck, 1984; Matsumoto, 1992; Matsumoto & Ekman, 1989). For example, while accurately recognizing the facial expression 'anger,' the EA observer may instead choose a more socially acceptable emotion (e.g., 'sad') when describing the observed facial expression. Yet, while acknowledging that culture could influence the decoding of facial expressions via culture-specific 'decoding rules' as described above, the emotion literature has largely overlooked an extensive body of research showing that culture modulates visual perception, specifically categorical perception. Here, I will detail some of the main findings that demonstrate that culture influences visual perception.

1.8 Culture and Visual Perception

How can culture shape visual perception? As originally discussed by Helmholtz (Helmholtz, 1867/1925), human 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 previous experience (i.e., unconscious inference). Visual illusions provide some of the best demonstrations of how visual perception reflects the assumptions made about the visual environment rather than a direct translation of reality. To illustrate, observe the famous Checker-shadow illusion created by Edward H. Adelson (Adelson, 1995) shown below in Figure 1.3 (see Appendix for original source of image). In the image on the left, labeled 'Original Illusion,' observe squares 'A' and 'B' on the chequerboard: they appear to be different shades of grey, yet they are in fact exactly the same colour. How has the visual system misinterpreted reality? In the image, we can see the green cylinder has cast a shadow on the square 'B' on the chequerboard, but not on square 'A.' Via experiences of the visual environment, the knowledge that shadows misrepresent the true underlying colour of an object is acquired. Using this knowledge (i.e., unconscious inference), the visual system adjusts perception to obtain a more accurate representation of the true underlying colour (i.e., that square 'B' is lighter). Indeed, perception of square 'B' is adjusted towards a lighter shade rather than a darker shade due to inferences made about square ‘B.’ That is, based on the information provided in the image (the chequerboard is made from dark and light shades of gray) and previous knowledge of chequerboards (squares alternate in colours), the true underlying colour of square ‘B’ is inferred to be a light shade of gray[5].

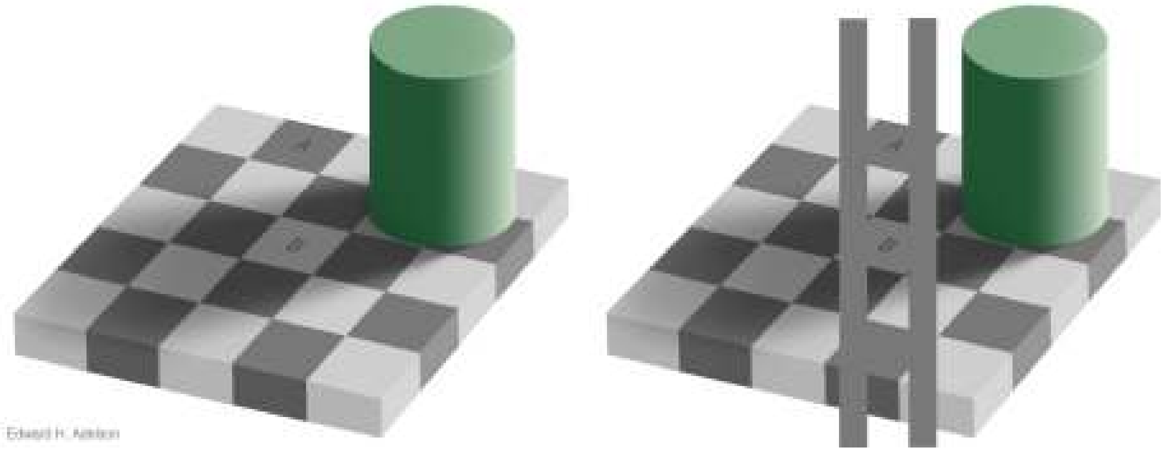

Figure 1.3 The Checker-Shadow Illusion – An Example of the Influence of Knowledge on Visual Perception. In the image presented on the left labeled ‘Original Illusion,’ observe squares ‘A’ and ‘B’ on the chequerboard: they appear to be different shades of grey – ‘A’ is a darker shade of gray than ‘B.’ Yet, as shown in the image presented on the right labeled ‘Proof,’ squares ‘A’ and ‘B’ are in fact exactly the same colour.

As demonstrated above using the Checker-Shadow illusion, knowledge and experience (in this case of shadows and chequerboards) can shape visual perception. Therefore information extracted by the visual system can be subject to different interpretations, depending on the knowledge and experience acquired (e.g., see Philippe G. Schyns & Rodet, 1997 for effects of learning on perception).

1.8.1 Knowledge, Concepts & Categorization

[5] Assumptions are also based on probabilistic reasoning, which are developed from previous experience of the environment and knowledge of patterns (conditional probabilities). For example, if we had to guess the colour of the last square on the checkerboard, knowledge that the rest of the board appears to be a regular pattern would guide our decision – i.e., the last square on the checkerboard is highly likely to be the same colour as two squares previous. We do so because the environment is constructed primarily of regular patterns, which thus provides predictive information. As a result, agents within the environment are better able to predict the likely events in the environment and prepare in advance a response for adaptive action.

Essentially, all knowledge and experience are used to create concepts – single complex units of information that represent objects[6] that can be used to predict the conditions of the environment. For example, in the Checker-shadow illusion above, the knowledge that shadows misrepresent the true underlying colour of an object forms part of the concept 'shadow.' By accessing this knowledge, one can predict that items under the shadow will be darkened, resulting in a perceptual adjustment. Similarly, additional knowledge about the physical properties of shadows (e.g., shadows obstruct light) retained as part of the concept 'shadow' predicts that objects underneath the shadow may be cooler than objects in direct sunlight. Accurate knowledge of whether the objects under the shadow would be lower in temperature than the objects under direct sunlight would depend on complex knowledge of the objects in question (e.g., material properties such as conductivity). The importance of acquisition of conceptual knowledge is clearly demonstrated in developmental studies. For example, Inhelder & Piaget (1958) showed that children make mistaken assumptions about the physical properties of objects as they have not yet developed a suitably comprehensive understanding of the environment (i.e., conceptual knowledge). For example, when asking a child whether a large, heavy block of wood will float or sink in water, the child will answer that the object will sink because it's heavy. Similarly, if asked the same question about a small, metal nail, the child will answer that it will float because it is light weight (Inhelder & Piaget, 1958). Of course, the opposite it true due to the operation of density (mass) on buoyant forces. Thus, all knowledge of an object is consolidated into a concept, which is retained for future use to interpret the environment. Clearly, each culture embraces a different conceptual framework of values, beliefs and knowledge (e.g., religion, ethical and moral codes, judicial systems, rules for social interaction, and so forth), which exerts a generic and powerful top-down influence on the perception and interpretation of the visual environment.

[6] Here, I refer to an 'object' in the philosophical sense. That is, a thing, being or concept that is tangible and accessible to human senses.

To illustrate, consider the following scenario: a respected member of the community has taken a male child and, over the course of several weeks or months, has trained the child to willingly accept anal penetration. In Western culture this act would be identified as a case of ‘grooming’ by a paedophile and that the adult in question should be imprisoned as punishment for the psychological and emotional damage inflicted. In contrast, the Kaluli of New Guinea would consider this scenario as one of the most important times of the child’s life – a rite of passage, which will transform the child into a man by receiving the ‘elixir or life’ (i.e., human semen). Without this experience, the child would not develop normally into adulthood and suffer ostracism at the hands of the community, with subsequent significant psychological and emotional trauma. Indeed, any parent preventing the child from obtaining this experience would be perceived as abusive and/or neglectful. As a result, such practices are an integral part of the community and constitute a normal part of child development. The adult in question would be thanked by the parents, celebrated by the community and recommended to the parents of other boys for their services in the future (Henrich, Heine, & Norenzayan, 2010) Here, the concept of ‘good parenting’ (e.g., healthy child development, child protection) is certainly shared between both cultural groups, but the informational content of the concept differs wildly: ‘anal penetration’ does not feature in (‘normal’) Western concepts of good parenting.

While this is a particularly striking example (which is by no means an isolated finding in terms of polar contrasts of human cognition and behaviour), I have used it to demonstrate the immense power of culture on shaping the perception and interpretation of the visual environment, specifically *categorical perception*. For example, Westerners would categorise the scenario as ‘child abuse,’ the adult as a ‘pedophile’ and the child a ‘victim.’ In contrast, the Kaluli of New Guinea would disagree, categorising the act as ‘child protection,’ the adult as ‘trustworthy and decent’ and the child as ‘proud and happy.’[7] Thus, culture (i.e., knowledge and concepts) shape how observers categorise objects in the visual environment. Although the above example is illustrative, the influence of culture upon categorical and visual perception is demonstrated in various empirical studies, of which I will detail the most cogent examples below.

1.8.2 Categorical & Visual Perception

One of the clearest examples of the influence of culture upon categorical and visual perception is a study conducted by Roberson et al., (2000) showing that culture shapes the categorization and perception of colour (see also Davidoff, Davies, & Roberson, 1999). In this study, English-speaking and Berinmo (of Papua New Guinea) observers were presented with 160 colour chips from the Munsell colour system (see Figure 1.4 below for an illustration of the Munsell system) where each chip represented a fully saturated colour, which varied along 2 dimensions - hue and lightness (i.e., ‘value,’ see Figure 1.4 below). All colour chips were equally spaced along both dimensions. Observers in each cultural group categorised each of the 160 colour chips according to the lexical terms used to represent different colours in the respective cultures (i.e., English speakers used 8 colour categories - ‘red,’ ‘pink,’ ‘orange,’ ‘yellow,’ ‘green,’ ‘blue,’ ‘purple,’ and ‘brown,’ whereas the Berinmo used 5 colour categories - ‘wapa,’ ‘mehi,’ ‘wor,’ ‘nol,’ and ‘kel’). By categorising the colour chips, each cultural group could therefore represent the concepts of each colour category comprising the wider conceptual framework, ‘colour.’

[7] This example also illustrates that the actions taken to uphold moral and ethical codes of each culture are culture-specific human constructs and not a reflection of what is intrinsically ‘natural’ or ‘wrong’ or ‘right.’ For example, child marriage is not fundamentally ‘wrong,’ as it believed in certain cultures, but reflects the universal desire to protect the child from future social ostracism.

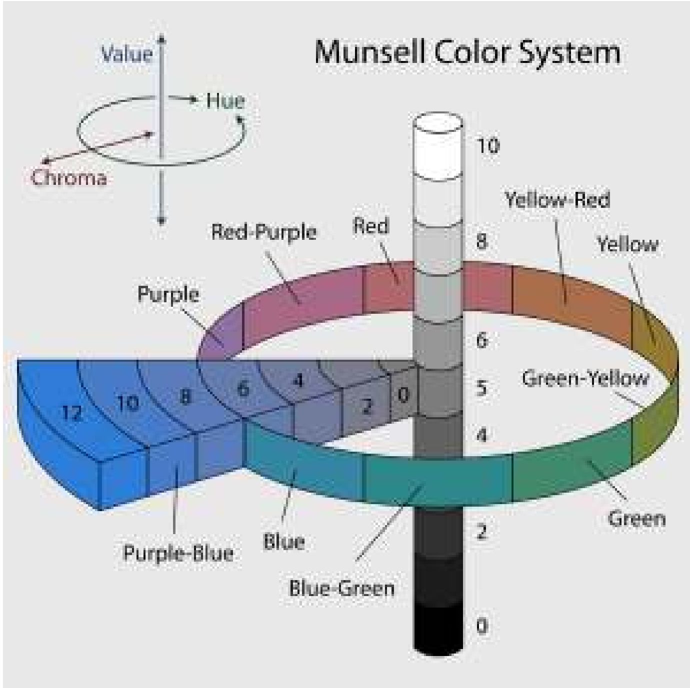

Figure 1.4 Illustration of the Munsell Colour System
The Munsell colour system is a colour space that describes colours as varying along three dimensions – hue (i.e., similarity to a unique hue – 'red,' 'blue,' 'green,' or 'yellow'), 'value' (i.e., lightness) and 'chroma' (i.e., saturation). The vertical columnar structure in the center represents 'value,' which ranges from 0 (black) to 10 (white). The triangular structure represents 'chroma,' which ranges from 0 (low saturation) to 12 (high saturation) and upwards (e.g., 30; not represented here), depending on the colour in question. Hue is represented by the circular array (positioned at 'value' 5, 'chroma' 6), which is divided in to 5 basic categories 'red,' 'yellow,' 'green,' 'blue,' and 'purple' with 5 overlapping secondary categories (e.g., 'blue-green'). Each exemplar in the Munsell colour system is coded based on the above 3 dimensions, with each exemplar equally spaced along each dimension.

Results revealed a striking cultural difference in the categorical perception of colour. For example, while the English speakers distinguished between 'blue' and 'green' colour chips, the Berinmo made no such distinction, instead categorising most 'green' and 'blue' (and some 'purple') chips as one colour – 'nol.' Similarly, the Berinmo distinguish between 'nol' and 'wor,' whereas the English speakers make no such distinction, distributing these colours amongst various other colour categories (e.g., 'green,' 'blue,' 'yellow,' 'brown' and so forth).

While the above results may appear to be simply an interesting 'difference of opinion' about colours across cultures, the implications are in fact much greater. Importantly, the authors demonstrate that categorical perception exerts a powerful influence upon visual perception itself (see also Roberson, Davidoff, Davies, & Shapiro, 2005). Specifically, that categorical perception creates the perceptual illusion that within category items appear more similar than between category items, even when the physical difference between exemplars is equal. For example, when presented with 3 consecutive (equally spaced) colours (e.g., 'green1,' 'green2' and 'yellow1') that straddle a culture-relevant categorical colour boundary (i.e., 'yellow'-'green' for English speakers) observers perceive the between-category colour (i.e., 'yellow') to be the most dissimilar of the three. In short, categorical perception distorts visual perception by creating an illusion of similarity/dissimilarity. Consequently, the illusion of similarity 'blinds' the observer to any novel categorical boundary that falls within a single established perceptual category. For example, the 'nol'-'wor' colour boundary passes through the colour category 'green.' Yet, the English speaker perceives all 'green' colours as ultimately homogenous, resulting in 'nol'-'wor' boundary 'blindness' a subsequent poor 'nol-'wor' discrimination performance, even after learning. In contrast, when presented with 'green' colours, the Berinmo are essentially confronted with what appears to be a random selection of colours from different colour categories (e.g., 'nol,' 'wor,' 'kel'), making the 'nol'-'wor' colour distinction easier than that experienced by the English speakers. The flip side is also true when Berinmo observers attempt to learn novel colour category boundaries such as the 'yellow'-'green' distinction – here, the Berinmo are effectively confronted with a homogenous sample of 'wor' colours and are no better at discriminating the 'yellow'-'green' boundary than another novel arbitrary colour distinction.

As demonstrated above, culture exerts a powerful influence upon the human visual system: culture-specific knowledge and conceptual frameworks shape categorical perception, laying down specific perceptual boundaries on the visual environment. Importantly, these boundaries create perceptual illusions that ultimately distort reality, giving rise to culture-specific perceptual experiences. Such 'top-down' cultural influences on the visual system are widely demonstrated by relative size judgments (Davidoff, Fonteneau, & Goldstein, 2008), change blindness sensitivities (Masuda & Nisbett, 2006), categorical reasoning styles (Norenzayan, Smith, Kim, & Nisbett, 2002) and eye movements (Blais, Jack, Scheepers, Fiset, & Caldara, 2008; Kelly, Miellet, & Caldara, 2010). However, as mentioned previously, the emotion literature has largely overlooked this large body of work when attempting to account for the significant cultural differences in the recognition of facial expressions of emotion. As yet, an explanation remains elusive.

1.9 Thesis Rationale

To obtain a clear understanding of the rationale for this thesis, it is useful to first recap on the information provided in the *General Introduction*.

1.9.1 Significant Cultural Differences in Facial Expression Recognition Are Unexplained

With biological and evolutionary origins, facial expressions have long been considered the 'universal language of emotion' with the six facial expressions of emotion – 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad' recognized at above chance performance across diverse cultures (Ekman, et al., 1987; Ekman, et al., 1969). Yet, some 'universal' facial expressions elicit significant cultural differences in recognition performance (H. A. Elfenbein & N. Ambady, 2002; Mesquita & Frijda, 1992; Russell, 1994). For example, facial expressions such as 'fear' and 'disgust' consistently elicit lower recognition performance among EA compared to WC observers (e.g., Biehl, et al., 1997; Chan, 1985; Matsumoto, 1992; Matsumoto & Ekman, 1989).

To account for the reported cultural differences in facial expression recognition, discussion and theoretical development generated a number of proposed differences in the transmission and decoding of facial expressions. For example, the 'neuro-cultural' framework proposed that culture-specific display rules could diminish the transmission of certain facial expressions, resulting in reduced experience and therefore accuracy of decoding such facial expressions (Ekman, 1972). Similarly, proposed culture-specific 'accents' or 'dialects' could introduce specific variations in the 'basic' facial expression signals, making accurate interpretation more difficult for out-group compared to in-group observers (H. A. Elfenbein & N. Ambady, 2002; Tomkins & McCarter, 1964). In addition, proposed culture-specific 'decoding rules,' which actively discourages explicit acknowledgement of certain facial expressions, could give rise to culturally biased response patterns rather than reflecting a recognition deficit *per se*.

Yet, with little empirical investigation, the origins of the reported cultural differences in recognition performance remain so far unexplained, as highlighted by Ekman in his book *'Emotions Revealed:'* "To this day, I do not know why 'fear' and 'surprise' [are] not distinguished from each other" (Ekman, 1992, pg 10). Thus, an empirical question remains unanswered – why do observers from different cultures systematically miscategorise the 'universal' facial expressions of emotion? Indeed, with increasing globalization and cultural integration, it is ever more important to understand how culture influences emotion communication. In this thesis, I will address this largely neglected and unexplained perceptual phenomenon. It is far beyond the scope of this thesis to provide empirical accounts for each and every culture that shows a significant deficit in the recognition of the 'universal' facial expressions. Here, I will focus on WC and EA observer groups, primarily because the differences in recognition performance are one of the most widely reported, yet currently unexplained (Biehl, et al., 1997; Matsumoto, 1992; Matsumoto & Ekman, 1989). For example, while WC observers recognize all 6 'universal' facial expressions with comparably high accuracy, EA observers systematically miscategorise 'fear' and 'disgust,' hereafter referred to as the 'EA recognition deficit.'

In light of the theoretical accounts and empirical data mentioned above, I will examine two key factors in a series of two experiments – cultural *decoding* of facial expressions and cultural *conceptions* (i.e., internal representations) of facial expressions. I will briefly detail each section below, providing the rationale for the underlying theory and methods used.

1.9.2 Cultural Decoding of Facial Expressions of Emotion

To examine cultural differences in the recognition of facial expressions, it is important to understand how observers decode facial expression signals. Decoding involves – a) the selection of information and b) the transformation of this information into a behavioural response. I will address each stage separately in Experiment 1 as detailed below.

Experiment 1: Eye Movements During Facial Expression Decoding

Categorization Task: First, I will demonstrate the robustness of the EA recognition deficit by replicating the reported behavioural results (i.e., certain 'universal' facial expressions elicit significantly lower recognition performance amongst EA compared to WC observers) using a 7 AFC facial expression categorization task. Importantly, I will use the so-called 'universal' FACS-coded facial expression of emotion (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad,' plus 'neutral') as they provide standardized facial expression signals. To further characterize the nature of the EA recognition deficit, I will examine the EA categorical confusions to reveal any consistencies in the categorization errors made. Specifically, I will show that EA observers systematically confuse 'fear' for 'surprise' and 'disgust' for 'anger.'

Eye Movements: Eye-movements provide an index of where overt attention is directed over time, thereby revealing the strategies of information selection during expression decoding. Therefore, to examine the selection of information during facial expression decoding (see point (a) above), I will use precision eye tracking technology to record the eye movements of observers while they perform the 7AFC categorization task. I will then use novel spatio-temporal analyses of fixations to examine the spatial location and temporal order of fixations to reveal the information sampled during facial expression decoding and visual strategies used to do so. Specifically, I will show that while WC observers sample the eyes and mouth, EA observers repetitively sample the eye region and neglect the mouth, particularly for facial expressions generating confusion.

Modelling Cultural Information Selection and Facial Expression Categorization: Using precision eye tracking technology and novel spatio-temporal fixation analyses to isolate the information selected during facial expression decoding. I showed that EA observers systematically sample the eye region and neglect the mouth, especially for facial expressions giving rise to the reported confusions. As explained in point (b) above, to understand the decoding process, it is important to examine the relationship between the sampled information and the behavioural responses of observers. Given that I am focusing on the EA recognition deficit (i.e., significantly poorer recognition of 'fear' and 'disgust'), I will dedicate this experiment to examining the decoding process of EA observers. Specifically, I will examine whether the eye information sampled by EA observers gives rise to the categorization confusions reported in Experiment 1 (these patterns of confusions are a robust phenomenon also replicated elsewhere; e.g., Matsumoto & Ekman, 1989; Moriguchi, et al., 2005). That is, are the eyes just too similar to distinguish certain facial expressions?

To test this hypothesis, I built a model observer that samples information from the face using a sampling method that approximates the human retina to categorise facial expressions. Importantly, the model observer represents an *objective* measure of whether ambiguous eye information gives rise to the reported EA confusions, as the model observer considers no other (uncontrolled) factors when categorising of facial expressions. In other words, by building a model observer, I can isolate and examine the factors relevant to my hypothesis (in this case, high similarity of sampled information generates categorization confusions). Using this method, I will reveal for the first time that the EA recognition deficit and corresponding categorical confusions, is due to a culture-specific fixation pattern that samples ambiguous information.

While providing an objective account of the origins of the EA recognition deficit and the categorization confusions, the results of Experiment 1 raise additional questions. For example, 'universal' FACS-coded facial expressions of 'fear' and 'disgust' consistently elicit significantly lower recognition performance amongst EA observers compared to WC observers, demonstrating that 'universal' facial expressions are not representative in EA cultures. How then are 'fear' and 'disgust' accurately represented in EA cultures? Also, why would EA observers systematically neglect critical face regions (i.e., the mouth) when decoding facial expressions of emotion? After all, the accurate recognition of facial expressions is an essential biological and social skill necessary in all cultures, and fixations ought to fall on diagnostic information. Therefore, does the diagnostic expressive face information differ across cultures?

1.9.3 Cultural Conceptions of Facial Expressions of Emotion

To address the above questions, I will examine how WC and EA observers conceptualize (i.e., internally represent) facial expressions of emotion. As mentioned previously, concepts are complex units of information corresponding to specific objects in the environment. For example, a concept relating to the emotion 'happy' will contain information regarding the characteristic expressive features of 'happy' facial expressions (e.g., wide, smiling mouth with wrinkling of the skin at the side of the eyes). Importantly, this information is created from previous experiences, which provides predictive information about the world, thus shaping expectations and guiding behaviour, including information sampling via eye movements (Blais, et al., 2008; Jack, et al., 2009; Kelly, et al., 2010). By examining the internal representations (i.e., concepts) of facial expressions, I can reveal the facial expression information that WC and EA observers have experienced in the past and those expected in the future.

Experiment 2: Cultural Internal Representations of Facial Expressions of Emotion

In this experiment, I will estimate and reconstruct the internal representations of the 6 'basic' facial expressions of emotion (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad') in WC and EA observers using a simple yet powerful psychophysical technique – reverse correlation (RC).

Reverse Correlation: As the term 'correlation' suggests, RC is well-known psychophysical technique that is used to ascertain the relationship between two variables. In this case, I used RC to ascertain the relationship between internal representations of facial expressions (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad') and information presented to the observer (i.e., expressive face features). To clearly illustrate this technique, I will briefly detail the nature of the information presented (i.e., the stimuli) the task, which correlates the two variables in question and the procedure to reconstruct the internal representations.

Stimuli: Since prescribed expressive face features (i.e., FACS-coded facial expressions) provide a limited and potentially biased sample of expressive information, I used stimuli that provide flexible and unbiased facial expression information. On each trial, a randomly generated white noise template is added to a 'neutral' expression face, which adds random expressive features by changing the pixel values of the face image. For example, the addition of white pixels to the light eye region may create the appearance of whiter eyes than the original non-expressive face. As a result, the observer may interpret the image as expressive. For example, if the observer perceives the stimulus as having very white eyes, the observer may categorise the stimulus as 'surprise' if the features match those of their internal representation. Thus, the stimuli provide flexible and unbiased information as the observer's response is driven by the influence of top-down (i.e., their internal representation) rather than bottom-up information. Furthermore, the presented information is not limited to prescribed expressive features.

Task: By categorising each stimulus according to the 6 'basic' facial expressions of emotion, the observer indicates which information corresponds to their internal representation, as described above using the very white eyes of 'surprise.' Each observer categorised 12,000 stimuli, thus producing a set of white noise templates for each facial expression that contains the information corresponding to the observer's internal representation.

Reconstruction of Internal Representations: To reveal the information consistently categorised (i.e., highly correlated) for each facial expression, the set of white noise templates are summed. Finally, the resulting classification image is added to the 'neutral' expression face to aid visualization of the internal representation.

Using this technique, I estimated and reconstructed the internal representations of each of the 6 'basic' facial expressions for each WC and EA observer, revealing the expressive facial features for each internal representation. To conduct cross-cultural comparisons of the expressive features for each internal representation, I used statistical image processing techniques, showing that facial expression signals differ across cultures.

2. Cultural Decoding of 'Universal' Facial Expressions of Emotion

2.1 Introduction

Although widely considered to be the 'universal language of emotion,' (FACS-coded) facial expressions of emotion such as 'fear' and 'disgust' consistently elicit lower recognition levels among EA compared to WC groups (see Elfenbein & N. Ambady, 2002 for a meta-analysis and ; Mesquita & Frijda, 1992; Russell, 1994 for reviews). Although the reported EA recognition deficit evoked discussion and theoretical developments in the literature (Matsumoto, 1992; Elfenbein, 2002), an empirical explanation of its origins remains elusive. Here, I will address this issue.

To investigate the origins of the EA recognition deficit, I will focus on the *decoding* of facial expressions of emotion in 2 culturally distinct groups of observers. That is, I will examine how the visual systems of culturally distinct observers systematically extract and categorise facial expression information. To this aim, I recorded the eye movements of WC and EA observers while they categorised the 6 'basic' 'universal' facial expressions of emotion, plus 'neutral' for same-race (SR) and other-race (OR) faces.

2.2 Methods

2.2.1 Observers

Thirteen WC (7 females) and 13 EA (12 Chinese, 1 Japanese, 8 females) observers participated (mean age = 24 years 5 months; 23 years 2 months, respectively). All EA participants were born in East Asia, arriving in a Western country (United Kingdom; UK) for the first time to attend the University of Glasgow. EA participants had been residing in the UK for 1 week on average at the time of testing. All participants had normal or corrected vision, gave written informed consent and paid £6 per hour for their participation. The Departmental Ethical Committee approved the experimental protocol.

2.2.2 Stimuli and Design

To isolate and examine the effects of decoding during facial expression recognition, I controlled for any potential cultural variations in the transmission of facial expression signals by using normalized, FACS-coded expressive faces – the so-called 'universal' facial expressions. Sourced from JACFEE and Japanese and Caucasian 'neutral' Faces (JACNeuF) databases (Matsumoto & Ekman, 1988), stimuli consisted of 56 images displaying 6 facial expressions ('happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad') plus 'neutral.' Gender and race of face were equally distributed in each facial expression category. Using Adobe™ Photoshop CS™, I cropped each image to remove any potentially idiosyncratic hairstyles and aligned the eye and mouth positions using Psychomoprh software (Tiddeman, Burt, & Perrett, 2001). I displayed the images (280 x 380 pixels in size) on a 1024 x 768 pixel white background using a 21" Iiyama HM204DTA monitor (refresh rate of 120 Hz) and used SR Research ExperimentBuilder software, version 1.4202 to control stimulus presentation. To replicate a natural distance for social interaction (Hall, 1966) and represent faces as the average size of a real face (Ibrahimagić-

Šeper, Čelebić, Petričević, & Selimović, 2006), I set the viewing distance at 60cm. Thus, images subtended 10° (horizontally) x 14° (vertically) of visual angle.

2.2.3 Procedure: Eye Movement Recordings

To record eye movements, I used an EyeLink II head-mounted eye tracker (SR International), which has an average gaze position error of <0.5°, a resolution of 1 arc minute and a linear output over the range of the monitor used. I set the sampling rate to 500Hz and used the pupil only mode during eye movement recording. I determined ocular dominance using The Miles test (Miles, 1930) and tracked only the dominant eye, although observers viewed images binocularly. To minimize head movements and maintain a standard viewing distance, I used a chin rest. Before testing, I performed a nine-point fixation calibration and validation procedure (implemented in the EyeLink API) to establish optimal calibration. A central fixation point appeared before each trial, which automatically calculated the drift correction. If drift correction exceeded 1° of visual angle, I repeated the calibration and validation procedure until optimal criteria were reached.

2.2.4 Procedure: Categorization of Facial Expressions of Emotion

I instructed observers to perform a 7 AFC facial expression categorization task with WC and EA faces. Prior to testing, I established familiarity with the expressions and their categorical labels by providing examples from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist, Flykt, & Öhman, 1998) and asking observers to provide correct synonyms and descriptions of each emotion category. During testing, stimuli appeared pseudo-randomly in one of four quadrants of the screen and remained until the participant responded. Observers registered their response by giving a manual response using a single button response pad, accompanied by a verbal response (to eliminate additional eye movements towards the response keys). I recorded responses throughout testing.

2.2.5 Analysis & Results

2.2.5.1 Task Performance: Facial Expression Categorization

To compare performance accuracy of WC and EA observers in categorising facial expressions, I conducted a 3-way (2 Cultures of observers, 2 Race of faces, 7 Facial expressions) mixed design ANOVA on mean categorization accuracy. Figure 2.1 summarizes the experimental design and presents categorization accuracy with a coloured bar for each condition. See also Table 1 for mean accuracies and standard errors for each condition of the experiment.

Figure 2.1 Mean Categorization Accuracies for Each Condition of the Experiment. Panel 'WC': Illustration of the experimental design for Western Caucasian observers categorising Same Race (row labeled 'SR') and Other Race (row labeled 'OR') faces across 7 expressions ('neutral,' 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad'). One face stimulus exemplar is shown per condition. Panel 'EA': Illustration of experimental design for East Asian observers for the same conditions. The coloured bar to the left of each face represents the mean categorization accuracy for that condition where red indicates a significant difference in categorization errors between observer groups ($P < 0.05$). Error bars report standard errors of the mean.

Table 1. Categorization Accuracy for Western Caucasian (WC) and East Asian (EA) Observers across All Facial Expressions and Same Race (SR) and Other Race (OR) Face Stimuli.

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

* $P < 0.05$ ** $P < 0.001$

A Culture of observer X Facial expression interaction was significant [$F(6,144) = 5.608$, $P < 0.001$], with post-hoc Bonferroni comparisons showing that EA observers made significantly more errors when categorising 'disgust' ($P < 0.05$) and 'fear' ($P < 0.001$) than WC observers (presented with a red coloured bar in Figure 2.1). In contrast, WC observers categorised all facial expressions with comparably high levels of accuracy. Closer inspection of the categorization errors also revealed that 'fear' and 'disgust' were consistently confused with 'surprise' (78% of errors) and 'anger' (72% of errors), respectively. Although consistent with previous observations (Ekman, et al., 1987; Matsumoto, 1992; and Matsumoto & Ekman, 1989; Russell, 1994), a critical question remains unanswered - why do EA observers recognize certain facial expressions (i.e. 'fear' and 'disgust') with significantly lower accuracy compared to WC observers? And why do EA consistently confuse 'fear' with 'surprise' and 'disgust' with 'anger?'

2.2.5.2 Spatio-temporal Fixation Patterns

Examination of the location, frequency and temporal order of fixations over the face can reveal the information selected to recognize expressions, and the strategy used to do so.

a) Fixation Location Across Face Features

To examine the location of fixations across face features, I first computed fixation maps for each condition of the experiment by plotting all fixation locations (x, y co-ordinate, from correct trials only) across time into a single 280 x 380 matrix. To accurately represent the foveated region (2° visual angle) for each fixation location, I smoothed each fixation with a Gaussian kernel ($\alpha = 10$ pixels).

Next, I established Face regions to provide a common frame of reference for describing the location of fixations in terms of face features. I calculated Face regions based on the contribution of all significantly fixated regions in each of the 28 conditions. First, I applied the *Pixel Test* ($P<.05$; Chauvin, Worsley, Schyns, Arguin, & Gosselin, 2005) to fixation maps in each condition to reveal the significantly fixated regions. Centroids were calculated for each resulting significant region in all conditions. I then pooled all centroids across conditions and performed a k-means cluster analysis (MacQueen, 1967) to calculate a single centroid for each non-overlapping significantly fixated region. For example, the *Pixel Test* showed significant fixations over the left eye in all twenty-eight conditions, resulting in 28 centroids, which I subsequently reduced to a single centroid. Significant fixations over the bridge of the nose appearing in the 'disgust' and 'anger' conditions only were still represented in the final Face regions. Therefore, each significantly fixated region appearing in each condition contributed to the resulting 5 centroids (corresponding to the Face regions 'Left eye,' 'Right eye,' 'Bridge of nose,' 'Centre of face,' and 'Mouth').

Figure 2.2 (Panel A) below shows the fixation distributions for each observer group collapsed across race of face and expression. Colour-coded distributions represent the density of fixations across Face regions, where red indicates the most densely fixated regions. Note that for

WC observers (upper fixation map), fixations are more evenly distributed across the face, whereas for EA observers (lower fixation map), fixations are biased towards the upper part of the face. These culture-specific fixation patterns are consistent across all 7 facial expressions of emotion and races of face, as shown in Figure 2.2 (Panel B). Face regions are colour-coded as follows: ‘Left eye’ – blue, ‘Right eye’ – green, ‘Bridge of nose’ – yellow, ‘Centre of face’ – orange, and ‘Mouth’ – red, with higher colour saturation indicating higher fixation density, shown relative to all conditions. Note that the red ‘Mouth’ fixations for EA observers are less intense compared to WC observers across all conditions, including ‘happy.’

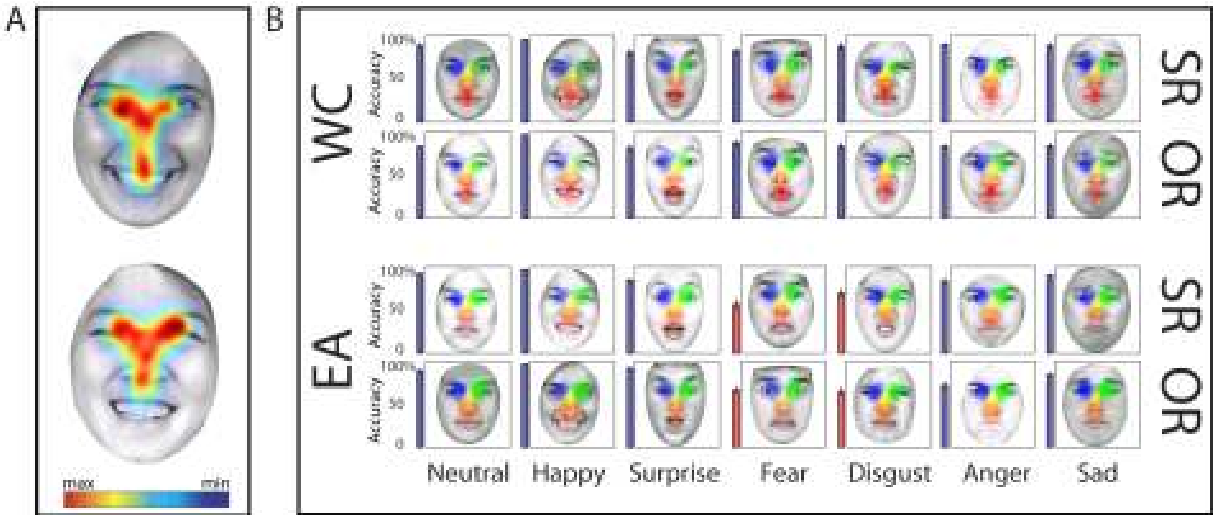

Figure 2.2 Fixation Distributions. Panel A: Fixation distributions for each observer group collapsed across Race of face and Expression. Colour-coded distributions represent the density of fixations across Face regions, with red showing the most densely fixated regions. Note that for EA observers (lower fixation map), fixations are biased towards the upper part of the face compared to WC observers (upper fixation map), where fixations are more evenly distributed across the face. Panel B: Fixation distributions for each condition of the experiment. Colour-coded distributions presented on gray-scale sample stimuli show the relative distributions of fixations across Face regions. Colour-coding is as follows: blue – ‘Left eye,’ green – ‘Right eye,’ yellow – ‘Bridge of nose,’ orange – ‘Centre of face,’ red – ‘Mouth.’ Higher colour saturation indicates higher fixation density, shown relative to all conditions. Note that the red ‘Mouth’ fixations for EA observers are less intense compared to WC observers across all conditions, including ‘happy.’ Colour-coded bars represent the mean accuracies for each condition, as in Figure 2.1.

To compare the mean number of fixations on Face regions (i.e. ‘Left eye,’ ‘Right eye,’ ‘Bridge of nose,’ ‘Centre of face’ and ‘Mouth’), I included the fourth factor of Face Region to the original ANOVA design. A significant Culture of observer X Face region interaction [F (4, 96) = 3.65, $P < 0.01$) with post-hoc comparisons showed that EA observers made significantly more left ($P < 0.01$) and right eye ($P < 0.001$) fixations compared to the mouth (Figure 2.2, Panel B summarizes this interaction with the corresponding fixation maps), even for 'happy' - a notable finding given that the mouth is clearly diagnostic for this expression(M. L. Smith, et al., 2005). In contrast, WC observers fixated all Face regions equally. I found no main effects for either Culture of observer or Race of face.

b) Minimum Description Length

As shown above in Figure 2.2, WC and EA observers differentially allocate attention to the eyes and the mouth. To further characterize biases in information sampling strategies, I analyzed the order in which the Face regions were visited using Minimum Description Length (MDL) analysis (Jorma, 1989, see Methods). MDL is a statistical method that extracts regular patterns from data set sequences (Jorma, 1989; Zhao, Serpedin, & Dougherty, 2006). Here, a pattern consists of the succession of fixations landing on Face regions (e.g., 'Left eye' - 'Right eye' - 'Left eye'). Fixation patterns are represented as a succession of colour-coded circles (e.g., blue - green - blue); with each circle representing a Face region (see fixation sequence indicated with a black arrow in Figure 2.3). To understand the outcomes of the MDL analysis presented in Figure 2.3, consider the sequence of fixations 'Left eye' - 'Right eye' - 'Left eye' in EA observers resolving 'fear' for OR faces (indicated with a black arrow in Figure 3). This sequence is represented with the succession of colour-coded circles (blue - green - blue), each corresponding to a Face region. In the same condition, the fixation sequence 'Right eye' - 'Left eye' - 'Right eye' is also represented using colour-coded circles (i.e. green - blue - green). All fixation sequences shown in Figure 2.3 are represented using colour-coded circles corresponding to Face regions.

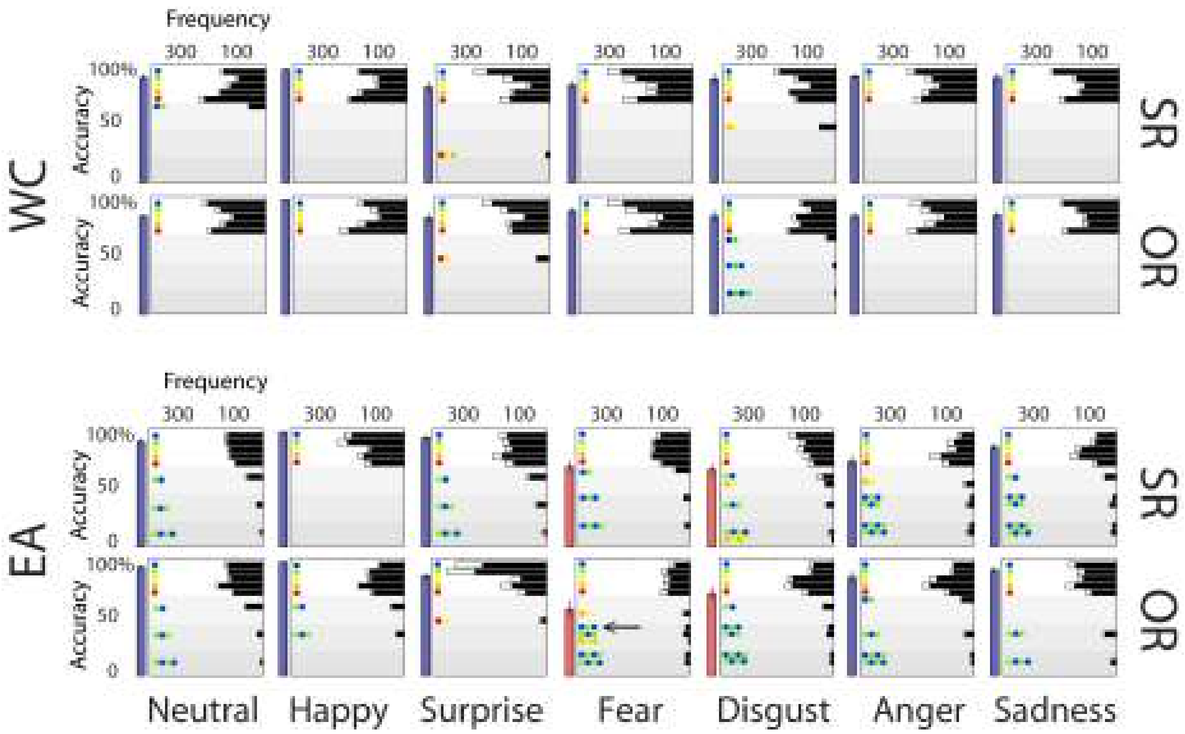

Figure 2.3. Fixation Sequences for Each Condition. Successions of colour-coded circles represent the fixation sequences extracted using Minimum Description Length (MDL) analysis with each circle representing a Face region. Face regions are colour-coded as in Figure 2.2 (Panel A). For example, the succession of blue - green - blue circles (indicated with a black arrow) corresponds to the fixation sequence 'Left eye' - 'Right eye' - 'Left eye.' Single colour-coded circles correspond to fixations that do not appear as part of a sequence. Black (and white) bars to the right of the fixation sequences represent how frequently the fixation sequence appeared in the data set, with black indicating correct trials and white indicating incorrect trials. Different levels of gray in each condition represent the order of the fixation sequences. Note the higher number of fixations sequences for EA observers compared to WC observers in all conditions. Colour-coded bars represent the mean accuracies for each condition, as in Figure 2.1.

I calculated fixation patterns by first categorising fixations on each trial by Face region (represented by a number for the purposes of analysis), based on their minimum distance to a Face region centroid. For example, a trial with three fixations (e.g., 'Left eye' - 'Mouth' - 'Right eye') would be represented as a sequence of three numbers (e.g., 1-5-2). A trial with five fixations (e.g., 'Right eye' - 'Left eye' - 'Right eye' - 'Mouth' - 'Left eye') would be represented as a sequence of five numbers (e.g., 2-1-2-5-1). I collapsed redundant fixation sequences (fixations occurring consecutively within the same Face region) into a single fixation (e.g., the sequence 2-2-1-3 would be re-coded as 2-1-3). Correct and incorrect trials contributed to the data set in each condition and I conducted MDL analysis on each condition separately. I conducted MDL analysis from zero (single fixation sequences) through first (two fixation sequences), second (three fixation sequences) and up to third order (four fixation sequences) in each condition. To eliminate fixation sequences occurring by chance, I used the Monte Carlo simulation method to simulate the fixations on each trial. I pseudo-randomly sampled the numbers, which corresponded to Face regions (i.e., numbers 1-5) with sampling biased to replicate the distribution of observer fixations across Face regions in each condition. I conducted 10,000 simulations per condition, and computed a frequency distribution for each fixation pattern. I then calculated the probability of each fixation pattern occurring, based on the number of times it appeared in the observer data set. Fixation patterns occurring significantly frequently were included in the results ($\alpha = 0.05$).

The results of the MDL analysis revealed a clear cultural contrast – EA observers made significantly more specific fixation sequences than WC observers (as shown by a Chi-square test of association [$\chi^2(1) = 366.79$, $P < 0.001$; note in Figure 2.3 the high number of colour-coded successions of circles for EA observers across conditions]. A significant majority of these fixation sequences involved exclusively the left and right eyes [$\chi^2(1) = 395.38$, $P < 0.001$], with significantly more used for negative (i.e. 'fear,' 'disgust,' 'anger' and 'sad') compared to other expressions [$\chi^2(1) = 15.97$, $P < 0.001$]. Interestingly, further inspection of categorization errors revealed that 'fear' and 'disgust' were consistently confused with expressions attracting similar fixation sequences (i.e., 'surprise' and 'anger'), respectively. Therefore, by persistently biasing fixations towards the eyes, it is possible that EA observers extract eye information that is just too similar to discriminate certain expressions.

At this juncture, it is important to now specifically examine the contribution of information sampling via eye movements to the reported EA behavioural deficit.

2.2.6. Procedure: Modelling Cultural Information Selection and Facial Expression Categorization

Behavioural and eye movement data show that EA observers consistently miscategorise facial expressions such as ‘fear’ and ‘disgust,’ which is associated with a culture-specific fixation pattern that samples information from the eyes while neglecting diagnostic information. Could the EA recognition deficit be due to an inadequate culture-specific decoding strategy that selects ambiguous information? To objectively determine whether sampling the eyes while neglecting more diagnostic face regions (e.g., the mouth for happy) could give rise to the reported EA behavioural confusions, I built a model observer that samples face information to categorise facial expressions.

2.2.6.1 Methods

2.2.6.1.1 The Model Observer

To objectively examine the contribution of culture specific information sampling to the reported EA behavioural confusions, I built a model observer which generated estimated patterns of confusions based on samples of face information (see Figure 2.4, Panel A for an illustration of the procedure).

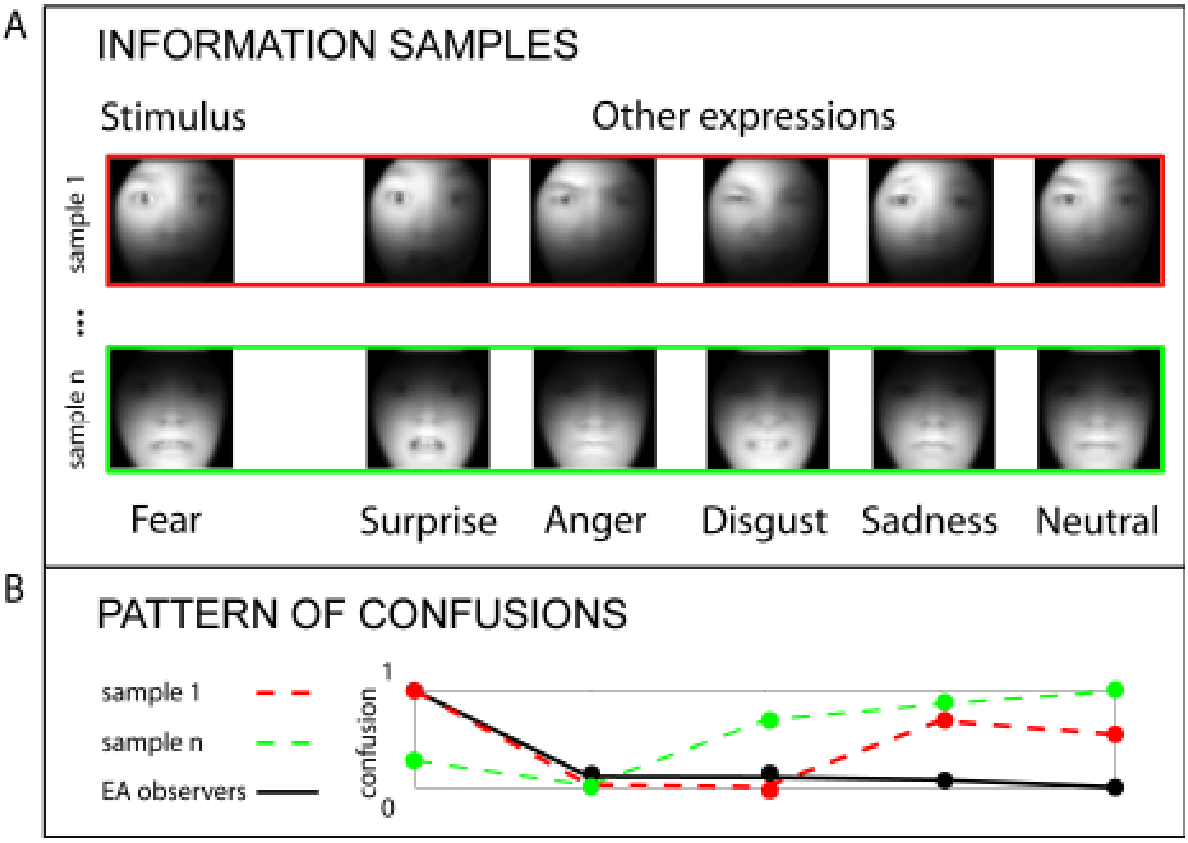

Figure 2.4 The Model Observer: Illustration of the Procedure to Compute Estimated Patterns of Confusion. Panel A: Information samples. To compute estimated patterns of confusion, the model sampled face information from the stimulus expression (e.g., 'fear') and from the same location on the other expressions (e.g., 'surprise,' 'anger,' 'disgust,' 'sad,' and 'neutral'). The face images illustrate an example of the information sampled. Panel B: Confusion patterns. The model then Pearson correlated the stimulus expression sample with each of the other expression samples. These correlations (plotted in dashed colour-coded lines beneath each corresponding face) represented the confusions of the model and were fitted (in a least means squared sense) against the behavioural confusions of the EA observers (plotted in black). The behavioural confusions of the EA observers were obtained by categorising each incorrect trial by response, for each expression (e.g., for 'fear' trials, the number of incorrect responses were computed for 'neutral,' 'surprise,' 'disgust,' 'anger' and 'sad'). I repeated the sampling and correlation process for 10,000 individual samples selected randomly across the face and finally sorted each information sample according to its fit to the behavioural confusions of the EA observers ('best' to 'worst' fits are shown in Figure 5, Panel A). I followed the same procedure for each expression.

a) Retinal Filter

The model observer obtained samples of face information using a method, which approximates the information extracted by the visual system during a fixation. To achieve this, I built a retinal filter which operated as follows: First, the image was linearly decomposed using

Fourier transform into a 4 level Laplacian pyramid (Simoncelli & Freeman, 1995), where each level contains distinct and non-overlapping spatial frequency information extracted from the original stimulus. Each level was then filtered by applying a Gaussian window (α = 10 pixels, to represent the fovea – 2° of visual angle) to the same relative image location, as specified by random co-ordinates (x, y) generated in each trial. After filtering, the 4 levels were recombined using Fourier transform to produce the desired image (see Figure 2.4, Panel A). Thus, the resulting image shows high spatial resolution information at the centre of the 'fixation' (i.e., the fovea) with increasingly lower spatial lower resolution information radiating outwards towards the periphery to emulate information extracted by the parafoveal regions.

b) Estimating Patterns of Confusion

To estimate a pattern of confusions (i.e. similarity) based on a sample of information, the model observer Pearson correlated the sampled information of the stimulus expression (e.g., 'fear' in Figure 2.4, Panel A) with information sampled from the same location of each of the other expressive faces (e.g., 'surprise,' 'anger,' 'disgust,' 'sad,' and 'neutral' in Figure 2.4, Panel A). The correlation values (plotted in dashed colour-coded lines in Figure 2.4, Panel B) represented the confusions of the model observer.

To illustrate, consider the facial information sampled by the model observer in Figure 2.4, Panel A. When sampling the eye region of 'fear,' the information is most similar (i.e. confusable) to that of 'surprise' and much less so for the other expressions (see red box). Thus, sampling from the eye region gives rise to a pattern of confusions (i.e. Pearson correlation values), represented by the red curve in Panel B. In contrast, sampling from the mouth region (see green box) produces a different pattern of confusions (green curve in Panel B) whereby 'fear' and 'surprise' are now distinguishable. Thus, each sample (i.e., 'fixation') is associated with a specific pattern of confusions.

c) Replication of East Asian Behavioural Performance

The model observer then fitted (using ordinary least square) each confusion pattern (plotted in dashed colour-coded lines in Figure 2.4, Panel B) to the behavioural confusion pattern of the EA observers (data extracted from Experiment 1, plotted in black in Figure 2.4, Panel B). For example, sampling the eye region (red box) produces a pattern of confusions (red curve) that more closely fits those of the EA observers, relative to samples from the mouth (green curve). The behavioural confusions of the EA observers were obtained by categorising each incorrect trial (extracted from Experiment 1) by response for each expression (e.g., for 'fear' trials, the number of incorrect responses were computed for 'neutral,' 'surprise,' 'disgust,' 'anger' and 'sad').

2.2.6.1.2 Stimuli

Stimuli consisted of 6 gray-scale face images, each displaying one of 6 facial expressions of emotion ('neutral,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad.' 'Happy' was not included as it was seldom confused with any other expression). I computed each facial expression image by averaging across 8 identities (half female, half EA) sourced from the JACFEE and JACNeuF databases (Matsumoto & Ekman, 1988) each of which were coded according to FACS. Prior to averaging, I aligned each face on the eye and mouth positions using Psychomorph software (Tiddeman, et al., 2001) and cropped the final image around the face using Adobe Photoshop CS® to remove hair.

2.2.6.1.3. Simulation of Information Extraction for Facial expression Categorization

For each facial expression (i.e., 'neutral,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad'), the model observer randomly sampled 10,000 individual samples from the face and calculated a pattern of confusions for each sample – i.e. for each pixel of the face serving as center of fixation. Finally, the model observer computed an ordinary least square fit of each pattern of confusion to the EA behavioural pattern of confusion. The model observer conducted the same procedure on each facial expression separately.

2.2.6.2 Analysis: Isolating information selected during facial expression confusions

To reveal the face information, which most closely reproduced the behavioural confusions of the EA observers, I sorted each information sample according to its fit to the behavioural confusions of the EA observers. I followed the same procedure for each of the 6 facial expressions. Figure 2.5, Panel A shows the rank order of all information samples according to their fit to the EA observer behavioural confusions, from best (red, $R^2 = 3.3$) to worst (blue, $R^2 = 4.6$) R^2 values, for each facial expression.

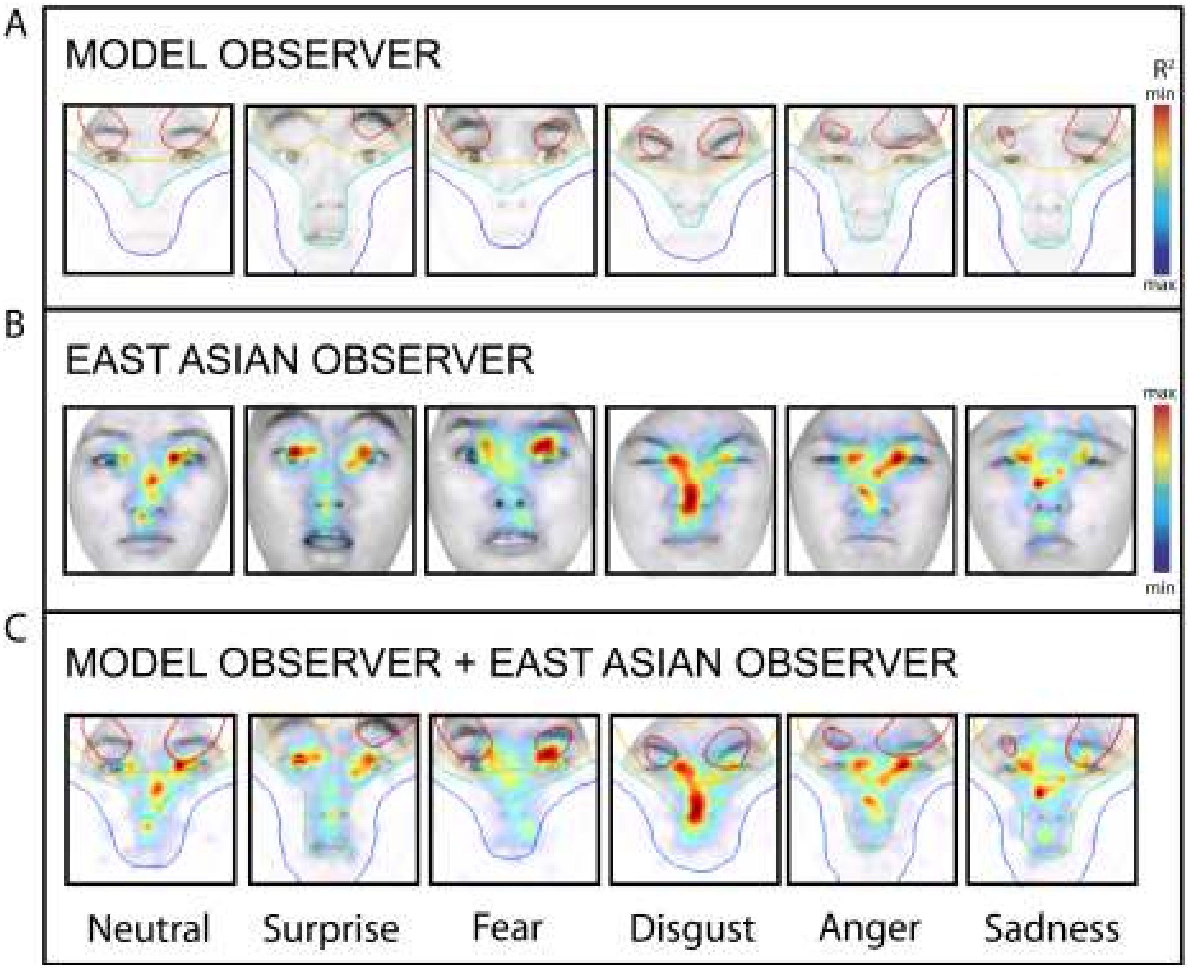

Figure 2.5 Comparison of Model Observer and EA Observers. Panel A: Rank order of samples extracted by the model observer. For each expression, all samples were ranked according to fit (R^2) of model pattern of confusions to the EA observer behavioural pattern of confusions. Rank order is indicated by colour-coded lines, with red showing the 'best fit' ($R^2 =$ 3.3). For example, consider the results for 'fear' – by sampling the eye brow (delimited in red) and eye region (delimited in orange) the model produced a pattern of confusions most similar to that of the EA observers. In contrast, the lower part of the face (delimited in blue and green) produced a pattern of confusions most dissimilar ($R^2 = 4.6$) to that of the EA observers. Panel B: EA observer fixation maps. For each expression, fixations leading to behavioural confusion errors are shown by relative distributions presented on gray-scale sample stimuli. Red areas indicate higher fixation density for each expression. Note the higher density of fixations in the upper part of the face for each expression. Panel C: Model observer and EA observer fixation maps. Note the higher density of EA observer fixations (represented by red areas) within the face regions ranked as 'best fit' (areas delimited in red and orange). By mirroring the behavioural confusions of the EA observers, the model observer produced a sampling bias towards the eyes and eye brows. 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).

2.2.6.3 Results

2.2.6.3.1 Information Selection - Model Observer vs. East Asian Observers

As shown, the model observer most closely replicated the EA observer pattern of confusions when sampling the eye (delimited in orange) and eyebrow (delimited in red) regions. Sampling from the lower part of the face (i.e. the mouth, delimited in light blue) produced the most dissimilar pattern of confusions. Panel B shows the fixation maps of EA observers during incorrect trials (data extracted from Experiment 1). I computed the fixation maps for each facial expression show in Figure 2.5, Panel B in the same way as in Experiment 1 using only fixations from EA observer incorrect trials and collapsing across Race of face. Panel C shows the EA fixation maps aligned with the model predictions, confirming that the face regions fixated most are those predicted by the model. This demonstrates that the reported behavioural confusions of the EA observers are symptomatic of an information sampling strategy that selects ambiguous information (i.e. the eyes and eyebrows) and neglects more diagnostic features (i.e. the mouth).

2.3 Discussion

Here, I report a marked cultural difference in the categorization of facial expressions – EA observers categorised 'fear' and 'disgust' with significantly lower accuracy compared to their WC counterparts. Interestingly, EA observers systematically miscategorised 'fear' as 'surprise' and 'disgust' as 'anger,' as supported by the literature (e.g., Ekman, et al., 1987, pp 714). Eye movements also revealed a cultural contrast in how information is sampled from the face to decode facial expressions. While WC observers distributed their fixations evenly, EA observers biased theirs towards the upper part of the face, including the eyes. As shown by analysis of fixation sequences, EA observers systematically and repetitively sampled these regions when confronted with negative expression stimuli (e.g., 'fear,' 'disgust,' 'anger' and 'sad') including those giving rise to significant behavioural confusions (i.e., 'fear' and 'disgust')[8].

To objectively examine whether culture specific fixation patterns of EA observers could give rise to the reported behavioural confusions, I built a model observer. By 'fixating' different regions of the face, the model observer generated patterns of confusions based on the information sampled from the face. Examination of the patterns of confusions showed that the model observer replicated the reported behavioural confusions of the EA observers by mirroring their culture-specific fixation pattern (i.e., biasing fixations towards the eyes). In contrast, the model observer produced patterns of confusion most dissimilar to those of the EA observers by sampling information from the mouth – a region systematically neglected by EA observers. Using a model observer, I objectively demonstrate that by biasing fixations towards the eyes, EA observers sample information that makes certain facial expressions virtually indistinguishable (i.e., 'fear' from 'surprise' and 'disgust' from 'anger'), thus giving rise to a specific pattern of behavioural confusions.

[8] It is beyond the scope of the above experiment to reveal the time course of categorization of the facial expression stimuli (i.e., whether categorization occurred prior to eye movements or not).

Here, I focused on the *decoding* of facial expressions to investigate cultural differences in the recognition of facial expressions. To interpret my results, let us first consider what decoding involves – a) the selection of information and b) the transformation of this information into a behavioural response. Our data clearly show that WC and EA observers differ on both accounts. However, in order to explain the EA behavioural deficit, we must understand the nature of the transformation.

EA observers persisted in fixating the eye region of facial expressions associated with behavioural confusions, despite the apparent lack of diagnostic information (P.G. Schyns, Petro, & Smith, 2007; M. L. Smith, et al., 2005). Yet, when confronted with potentially ambiguous (i.e., non-diagnostic) information, EA observers nevertheless showed a bias in their behavioural response, tending to categorise the stimulus as the less socially threatening of the two – 'surprise.' This suggests that the categorization of facial expressions may be influenced by a conjunction of information sampling via eye movements and cultural motivations to discourage the recognition of negative expressions. However, contrary to current hypotheses regarding 'decoding rules,' my results do not support the notion that negative facial expressions are initially recognized accurately before being substituted by a more socially acceptable emotion (Buck, 1984; Matsumoto, 1992; Matsumoto & Ekman, 1989 and) or judged as less intense (Ekman, et al., 1987; Matsumoto & Ekman, 1989). My eye movement data refute this: EA observers biased their fixations away from diagnostic information. Indeed, this is puzzling in itself – why would Easterners use a fixation pattern that neglects diagnostic information? After all, the accurate recognition of facial expressions is a biological skill necessary for human social interaction, and fixation patterns should centre on diagnostic information, in any culture.

Cultural differences in fixation patterns may reflect cultural specificity in the *transmission* of facial expression signals. This could shape EA observers to fixate subtle emotional cues around the eyes (Yuki, Maddux, & Masuda, 2007). Indeed, Panel B of Figure 2.2

also reveals that EA observers fixated more towards the eyebrows. Though anecdotal, this pattern is similar to Eastern emoticons where (^.^) is used for 'happy', (;_;) for 'sad' and (O.O) for 'surprise' (Pollack, 1996). Direct foveation of the eye region implies extraction of fine-grained information extraction, in contrast to the coarse-grained, global information implied by the majority of central fixations in EA observer face identification (Blais, et al., 2008). It must be stressed that FACS-coding is an agreed norm for WC expressions of emotion, and WC observers did indeed categorise each expression accurately. Therefore, when interacting with Westerners, Easterners will tend to be confronted with FACS-coded expressions rather than those displayed in their own culture, potentially leading to cultural misunderstandings.

Finally, I clearly show that EA observers do not avoid eye gaze during facial expression decoding, questioning the role of gaze avoidance in face processing among EA observers. For example, recent research showed that EA observers avoided the eye region in favour of a central fixation strategy for face identification (compared to WC observers who distributed fixations across the eyes and mouth (Blais, et al., 2008). My data suggest that culture-specific fixation patterns used by WC and EA observers for face processing (i.e., identification and emotion recognition) are not influenced by gaze avoidance, but rather reflect strategies developed to achieve diagnostic recognition. My data, together with recent research (Blais, et al., 2008), demonstrate genuine perceptual differences between EA and WC observers, showing that face processing is not universal across tasks. The extent to which human visual perception is shaped by cultural ideologies (e.g., individualism in Western culture and collectivism in Eastern culture) to produce different processing strategies (e.g., analytical amongst Westerners compared to a global processing style amongst Easterners) remains an interesting consideration open to further scientific scrutiny (see Han & Northoff, 2008 for an overview).

2.4 Conclusions

In sum, my behavioural and eye movement data provide new insights into cultural differences in the decoding of facial expressions of emotion. While WC observers distribute fixations evenly across the face, EA observers systematically miss critical aspects of FACS-coded faces (e.g., Action Units 20, 26 and 27) that are important for recognizing expressions such as 'fear' and 'disgust' (M. L. Smith, et al., 2005).

In the above validation study using a model observer, I showed that by sampling information from the eyes, the model observer is unable to distinguish certain facial expressions, leading to a pattern of confusions most similar to that of EA observers. Therefore, my data show that the EA behavioural deficit is due to a culture-specific fixation strategy that selects ambiguous information (i.e., persistent sampling of the eye region while neglecting more diagnostic regions such as the mouth).

Importantly, these results have implications for future studies using brain imaging technology. Culture-specific biases in visual information sampling strategies are likely to correspond to modulated neural signals, therefore constituting a potential source of variance in measured brain activity. With a recent surge of costly brain imaging research, my data therefore makes a timely contribution to practical aspects of new research methods, including electroencephalography (EEG), functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG).

3. Internal Representations of Facial Expressions of Emotion

3.1 Introduction

Although FACS-coded facial expressions represent 'universal' signals of emotion, significant cultural difference in recognition performance are reported throughout the literature (Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Matsumoto, 1992; Matsumoto & Ekman, 1989). Specifically, while WC observers recognize all 6 'basic' facial expressions with comparable accuracy, EA observers consistently miscategorise ‘fear’ and ‘disgust.’ In addition, WC and EA observers sample different information during facial expression recognition via culture-specific fixation patterns – WC observers fixate the eyes and the mouth, whereas EA observers bias fixations towards the eyes and away from diagnostic information (i.e. the mouth). Robust cultural differences in recognition performance, coupled with culture-specific decoding strategies question whether ‘universal’ FACS-coded facial expressions accurately represent human emotion in all cultures.

With such a broad impact of culture upon social behaviour and visual experience, observers from different cultures are likely to have developed markedly different internal representations of facial expressions of emotion, reflecting both past experience and future expectations. However, with no objective method available to accurately access the mind of individual observers, obtaining direct and detailed evidence of culture-specific internal representations of facial expressions has remained challenging and elusive. Here, I will address this issue using a powerful reverse correlation (RC) technique to access the “mind’s eye” of two culturally distinct observer groups (see alsoAhumada & Lovell, 1971; Gosselin & Schyns, 2003; Kontsevich & Tyler, 2004 for examples of the application of the RC technique). For each individual observer, I estimated, reconstructed and analyzed their internal representation of each of the six ‘basic’ expressions of emotion: ‘happy,’ ‘surprise,’ ‘fear,’ ‘disgust,’ ‘anger’ and ‘sad.’

3.2 Methods

3.2.1 Observers

Two cultural groups of observers participated – WC and EA. The WC group consisted of 15 observers (14 European, 1 North American, mean age 27.3 years (s.d. 6.4 years) 8 males), and the EA group consisted of 15 observers (15 Chinese, mean age 23.5 years (s.d. 2.1 years) 5 males). All EA observers were born in East Asia, having arrived in a Western country (UK) for the first time, with an average residence of 1.8 months (s.d. 2.1 months) duration and a minimum

International English Language Testing System score of 6.0 at the time of testing. All subjects had normal or corrected-to-normal vision, gave written informed consent, and paid £6 per hour for participating. The University of Glasgow Department of Psychology ethical committee approved the experimental protocol.

3.2.2 Stimuli

Each experimental stimulus consisted of the same background stimulus (a gray-scale, racially ambiguous 'neutral' expression face, with gray-levels scaled to between 100 and 130, on an 8-bit scale ranging from 0 to 255) superimposed with a different pattern of uniform white noise (in the gray-level range of -50 to +50) – see Figure 3.1, Panel A for an illustration. I computed the background 'neutral' expression face by averaging across 8 identities (half female, half EA, (Matsumoto & Ekman, 1988), previously cross-culturally verified as 'neutral' (e.g., Biehl, et al., 1997; P. Ekman, et al., 1987; Paul Ekman, Sorenson, & Friesen, 1969; Jack, et al., 2009; D. Matsumoto, 1992; David Matsumoto & Ekman, 1989; Moriguchi, et al., 2005). Prior to averaging, I aligned each 'neutral' face on the eye and mouth positions using Psychomorph software (Tiddeman, et al., 2001) and cropped the final image around the face using Adobe Photoshop CS®.

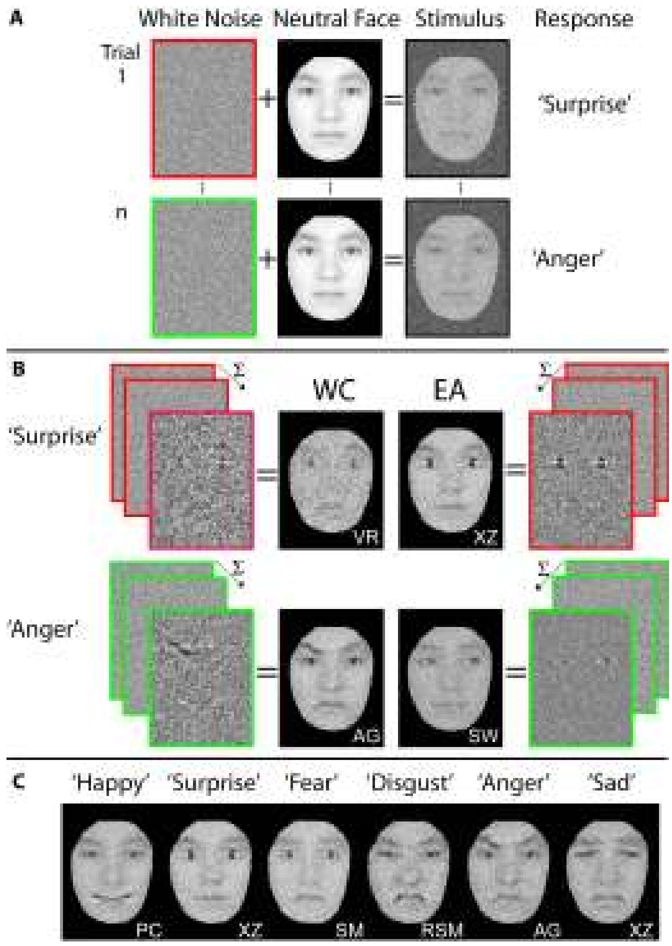

Figure 3.1 Illustration of the Reverse Correlation (RC) Technique. (A) Stimulus generation and procedure. On each trial, I added white noise a 'neutral' face, thereby adding random features. Naïve observers categorised 12,000 such stimuli according to 6 facial expressions of emotion, thus producing a set of white noise templates per emotion category. **(B)** Reconstruction of estimated internal representations. For each observer (e.g., WC observers 'VR,' and 'AG,' and EA observers 'XZ' and 'SW'), I summed the set of white noise templates in each emotion category to reveal the features used consistently for categorization. I then added the resulting features to the 'neutral' face to aid visualization of the internal representation. **(C)** Each face shows the internal representation of a facial expression of emotion estimated using RC. Each internal representation is selected from a different observer (i.e., 'PC,' 'XZ,' 'SM,' 'RSM,' 'AG,' and 'XZ') across WC and EA groups.

3.2.3 Design and Procedure

On each trial of the Experiment, adding white noise to the racially and emotionally 'neutral' expression face added random features. Observers will tend to interpret the resulting image as expressive if the added features correspond to those in their internal representation. For example, if the observer perceives wide opened eyes in the presented image, and their internal representation of 'surprise' contains this feature, the observer will interpret the image as 'surprise' (see Figure 3.1, Panel A).

I instructed observers to perform a 7AFC facial expression categorization task according to the 6 'basic' facial expressions of emotion (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad'), plus a 'don't know' response. Observers each categorised 12,000 such trials according to the 6 'basic' facial expressions of emotion, thus producing a set of white noise templates associated with each subjective categorical judgment (see Figure 3.1, Panel B for colour-coded examples, with red for 'surprise' and green for 'anger'). Observers viewed stimuli (380 x 280 pixels) on a mid-gray background displayed on a 19-inch Flat Panel monitor. A chin rest ensured a constant viewing distance of 85cm with images subtending 4.9° (horizontally) x 6.8° (vertically) of visual angle. Each stimulus remained visible until the observer responded using a keyboard. Prior to the Experiment, I established observer familiarity with the emotion categories by asking observers to provide correct synonyms and descriptions of each emotion category. All observers remained naïve as to the 'neutral' nature of the underlying background face throughout testing.

3.2.4 Computation: Estimating Internal Representations of Facial Expressions.

For each observer, to estimate the internal representation of each of the 6 'basic' facial expressions, I first summed the set of white noise templates in the relevant category (e.g., 'surprise' outlined in red) before smoothing with a Gaussian kernel ($\sigma = 3$ pixels) – see Figure 3.1, Panel B for an illustration. This summed white noise represents the changes in gray-level pixel values that, added to the 'neutral' face, lead the observer to perceive one of the emotions. After Z-scoring, I applied a statistical threshold (P <.05; Chauvin, et al., 2005) to isolate the significant pixels for further analysis (not shown in Figure 3.1, panel B). To visualize internal representations, I added the unthresholded summed set of white noise templates to the 'neutral' face. As a result, each internal representation contains the features the observer expects to constitute a particular facial expression. For example, as shown in Figure 3.1, Panel B, the internal representation of 'surprise' for WC observer 'VR' contains features from the raised rounded eyebrows, wide-opened eyes and the rounded mouth whereas for EA observer 'XZ' the internal representation comprises only the wide-opened eyes. To represent each cultural group, I computed average internal representations for each emotion category. Figure 3.2 below shows the average cultural internal representations for each of the 6 facial expression categories, calculated by averaging the noise template across all observers in each cultural group.

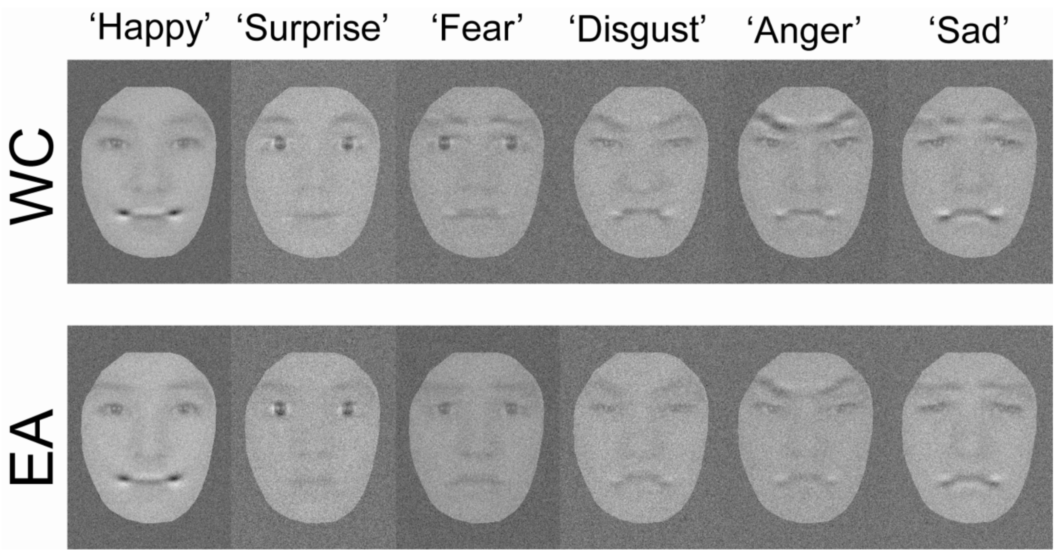

Figure 3.2. Average Cultural Internal Representations. Each row of faces shows the average internal representations of each cultural group (i.e., 'WC' and 'EA'), calculated by averaging the noise templates across all observers. Each facial expression category (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger,' and 'sad') is depicted separately.

3.2.5 Computation: Statistics over Facial Features.

To describe the location of significant information in the internal representations of the cultural groups, I first established 5 face regions of interest (corresponding to 'left eyebrow,' 'right eyebrow,' 'left eye,' 'right eye' and 'mouth') since most statistically significant pixels were represented in these regions (78.4% and 70.8% of statistically significant pixels for WC and EA observers, respectively). To analyze cultural differences, I compared the number of WC and EA observers representing features in each of the face regions of interest – specifically, 'left eyebrow,' 'right eyebrow,' 'left eye,' 'right eye' and 'mouth.' After isolating the significant pixels for each observer and facial expression independently, I summed the templates across all 15 observers in each cultural group and established a threshold number of significant pixels ($\partial >= 10$) per face region. Then, I conducted Chi-squared tests of association across the resulting WC and EA group templates, which revealed consistent culture-specific biases across all 6 facial expressions ($p <.05$). Figure 3.3 illustrates the results for each facial expression using colour-coded regions to indicate cultural bias strength (red indicates a strong WC bias; blue indicates a strong EA bias, with the maximum bias as 15 observers in one group reconstructing a face feature vs. 0 observers in the other cultural group).

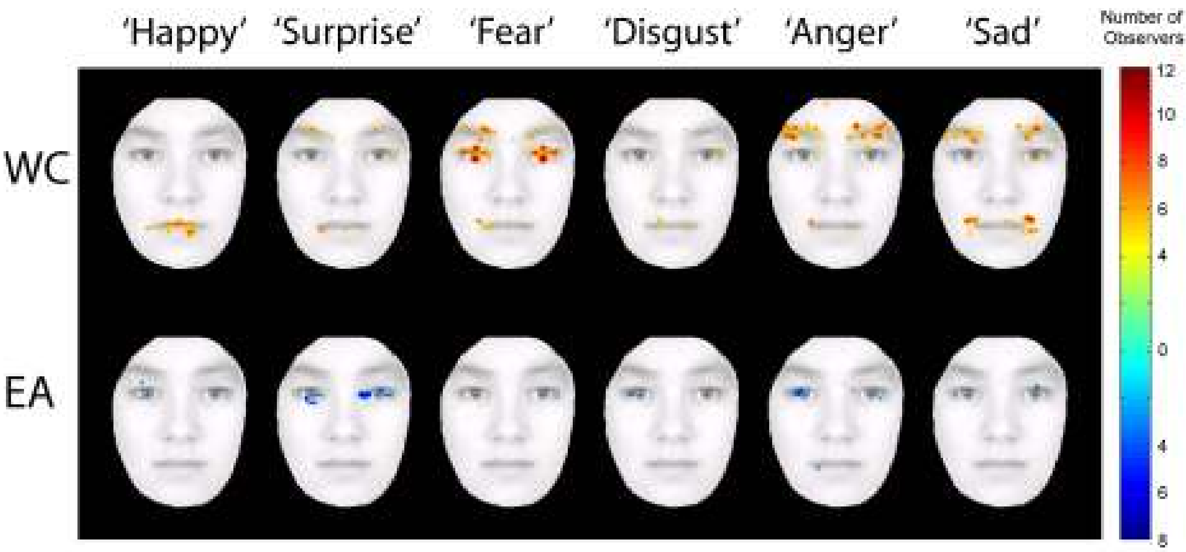

Figure 3.3 Cultural Biases in Features. In each row (WC and EA), colour-coded areas (red corresponding to WC observers and blue corresponding to EA observers) presented on gray-scale 'neutral' faces show the cultural biases ($P<.05$) in the reconstruction of features for each

facial expression of emotion. Magnitude of bias (i.e., absolute difference in the number of observers) is represented by colour-coded bar to the right. For example, consider 'surprise:' while 7 more WC than EA internal representations contained the eyebrows and mouth (indicated by red areas on 'neutral' face), 8 more EA than WC internal representations contained the eyes (indicated by blue areas on 'neutral' face).

3.3 Results

3.3.1 Cross-cultural comparisons

As shown in Figure 3.3 (top row), WC internal representations contained the eyebrows and the mouth significantly more than in EA representations. In contrast, EA representations (Figure 3.3, bottom row) largely contained the eyes, while neglecting other features compared with WC observers. Such differences contradict the universality hypothesis, which would predict reconstruction of similar features across WC and EA groups, instead supporting theories of cultural differences in facial expression signals.

Further inspection of the data revealed another intriguing cultural difference – gaze avoidance, shown only in the EA group. Five EA observers reconstructed gaze avoidance in at least one facial expression each (see Figure 3.4 for examples of individual EA observer data), whereas no WC observers showed any gaze avoidance. Although not pervasive across the group, gaze avoidance nevertheless emerged as a unique feature amongst EA observers, as predicted by literature (e.g., Knapp & Hall, 2005), and therefore validating my methods to reveal cultural differences.

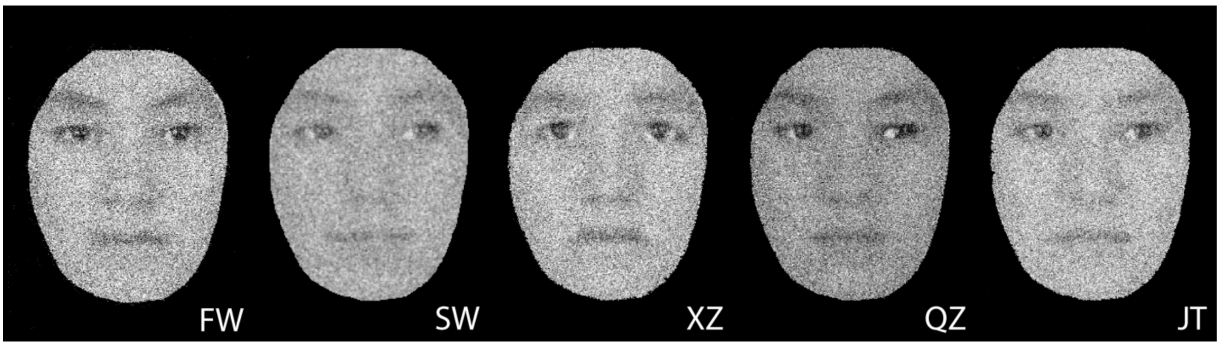

Figure 3.4 Gaze Avoidance in East Asian Internal Representations of Facial Expressions of Emotion. Each face demonstrates the use of gaze avoidance to communicate emotion. Each

example is selected from a different East Asian observers (i.e., ‘FW,’ ‘SW,’ ‘XZ,’ ‘QZ’ and ‘JT’) pertaining to the following emotions: ‘disgust,’ ‘anger,’ ‘fear,’ ‘surprise,’ and ‘surprise,’ respectively. No Western Caucasian observers showed any gaze avoidance in their internal representations.

3.4 Discussion

Using templates of white noise, I randomly added features to a racially and emotionally ‘neutral’ face, and instructed observers from two culturally distinct groups to categorise each image by facial expression. I then reconstructed the internal representations of each facial expression in both cultural groups of observers, using statistical image processing techniques to examine the properties of each internal representation. I revealed clear cultural differences in the internal representations of 6 facial expressions of emotion. Specifically, while WC representations distributed expressive features across the face (e.g., the eyebrows and mouth), EA representations showed a consistent bias in reconstructing information from the eyes. Further inspection of the EA bias also revealed a unique feature in the EA group - gaze avoidance.

To interpret my results, it is important to first consider what an internal representation represents. Created from experiences with the environment, internal representations provide predictive information about the world, shaping expectations and guiding behaviour, including information sampling via eye movements (Blais, et al., 2008; Jack, et al., 2009; Kelly, et al., 2010). Therefore, by estimating the internal representations of facial expressions of emotion in two culturally distinct groups, I captured culture-specific information that reflects both past experience and future expectations of facial expression signals. My data show that WC and EA observers expect emotion to be expressed using distinct facial expression signals, thus supporting views of cultural specificity in facial expressions.

Cultural specificity in the facial expression signals shown here may reflect contrasts in the experience of and exposure to facial expression signals across cultures, demonstrating cultural diversification of signals used for emotion communication. Rather, ecologically valid representations of facial expression signals would include expressive features characteristic of the culture. For example, I show that observers within the EA group expect gaze avoidance to be a component of facial expression signals, which currently does not feature in facial expression stimuli widely used in research. Furthermore, while modulations in gaze play a social role in revealing source of attention (see Kingstone, 2009; Klein, Shepherd, & Platt, 2009 for reviews), my data show that gaze direction plays a wider role in social interaction by providing information relating to internal emotional states.

Culture-specific expectations of facial expression signals also likely contribute to the reported consistent cultural differences in the recognition of 'universal' facial expressions (e.g., Biehl, et al., 1997; P. Ekman, et al., 1987; Paul Ekman, Sorenson, & Friesen, 1969; Jack, et al., 2009; D. Matsumoto, 1992; David Matsumoto & Ekman, 1989; Moriguchi, et al., 2005), as information conflicting (or mismatching) with internal representations would generate confusion. Moreover, the locations of expected expressive features reported here are consistent with culture-specific fixation patterns used during facial expression decoding (Jack, et al., 2009; see also Yuki, et al., 2007), highlighting the role of top-down factors on biological visual systems in the selection of diagnostic information. Thus, culture-specific fixation patterns that sub-sample culturally incongruent facial expressions would further hinder the decoding process, resulting in confusion.

At this juncture, it is worth noting that although eye movements were not recorded during the RC experiment, the bias in feature reconstruction by the EA is unlikely to be an artifact of a culture-specific bias in fixation strategy (as shown in Experiment 1). First, the visual system does not rely solely on the information subtending the centre of each fixation (i.e., 2° of visual angle; the fovea) to resolve perceptual tasks. Rather, at each fixation, the retina is stimulated by information subtending the entire visual field (i.e., foveal, parafoveal, peripheral). Thus, fixations do not bias information extraction to the fovea (or to any other visual field). For example, Blais et al., (Blais, et al., 2008) showed that EA observers identify faces by fixating an information-poor region of the face (i.e., the nose), demonstrating a dissociation between fixation location and information extraction (see also Roberto Caldara, Zhou, & Miellet, 2010). Secondly, while fixations can show the information extracted by the retina, they cannot reveal the information that is actually used by the observer to resolve the task. For example, consider that each fixation landing on the face extracts information from all features (e.g., eyes, nose mouth) by virtue of the wide visual field. Yet, to resolve the task of emotion categorization, observers use only specific samples of the information extracted by each fixation (M. L. Smith, et al., 2005). Given that fixations a) lack specificity in the information used to resolve perceptual tasks and b) do not correspond with the location of diagnostic features, their ability to bias information use is limited and unlikely to create artifacts in data collection used with RC.

3.5 Conclusions

For the first time, I estimated and reconstructed the internal representations of the 6 'basic' facial expressions of emotion in two culturally distinct groups of observers. Using statistical image processing techniques to examine the signal properties of the internal representations, I revealed significant differences in the expressive features used between the cultural groups – while WC internal representations contained significantly more eyebrow and mouth features, EA internal representations primarily featured the eyes. For the first time, my data *directly* show cultural specificity in the representation of facial expressions signals, challenging notions of a 'universal language of emotion.'

4. General Conclusions

In this thesis, I focused on investigating the origins of a well-documented but largely neglected and so far unexplained psychological phenomenon – the EA recognition deficit for certain ‘universal’ facial expressions. To account for the systematic differences in recognition performance between WC and EA observers when decoding ‘universal’ facial expressions of emotion, I examined two important sources of cultural variation over the course of two experiments – cultural *decoding* and *representation* of facial expression signals. I will briefly return to the main results of each experiment before discussing the wider implications.

Experiment 1: Cultural Decoding of ‘Universal’ Facial Expressions of Emotion

Task Performance: Here, I replicated the EA recognition deficit, demonstrating the robustness of the phenomenon - while WC observers recognize all 6 ‘basic’ facial expressions with comparably high accuracy (i.e., >85%), EA observers consistently miscategorised ‘fear’ and ‘disgust.’ Closer inspection of the data also revealed a systematic pattern of confusions – EA observers consistently miscategorised ‘fear’ as ‘surprise’ and ‘disgust’ as ‘anger.’ Importantly, such confusions are likely to have significant repercussions for cross-cultural communication as the mutual understanding of emotions is central to all human social interaction.

Eye Movements: Spatio-temporal analyses of eye movement data revealed a clear cultural contrast in the fixation patterns over face features used during the categorization of the 6 ‘universal’ facial expressions (plus neutral). Specifically, while WC observers distributed fixations evenly across the face (i.e., the eyes and the mouth), EA observers persistently biased fixations towards the eyes while neglecting the mouth, particularly for facial expressions giving rise to significant confusions (i.e., ‘fear,’ ‘disgust,’ and ‘anger’).

Modelling Cultural Information Selection and Facial Expression Categorization

To objectively determine whether the culture specific EA fixation pattern gives rise to the reported confusions, I built a model observer that samples information from the face to categorise facial expressions. Using this technique, I showed that the model observer replicated the EA confusions by mirroring the EA fixation pattern. For the first time, I revealed that the EA recognition deficit is due to a culture-specific fixation pattern that selects ambiguous information.

Experiment 2: Cultural Internal Representations of Facial Expressions of Emotion

As shown in Experiment 1, not only do EA observers consistently miscategorise certain 'universal' facial expressions, they also use a culture-specific fixation pattern that neglects critical face features (i.e., the mouth). Together, these results challenge the notion of a 'universal language of emotion' and support the view of cultural specificity in facial expression signals. To examine cultural specificity in facial expression signals, I used a powerful reverse correlation technique to reconstruct estimated culture-specific internal representations of the 6 'basic' facial expressions of emotion. For the first time, I provided a direct demonstration of cultural specificity in facial expression signals – while WC observers represented emotion using features distributed across the face, EA observers represented emotion primarily using the eyes and neglected the mouth, as predicted by culture-specific fixation patterns shown in Experiment 1.

Together, these data reveal for the first time the origins of a latent phenomenon – the EA recognition deficit – and challenge long standing notions of a 'universal language of emotion.' More specifically, these data directly question the validity of 'universal' facial expressions of emotion as representing truly universal signals of human emotion. Here, I will address the limitations of such stimuli – FACS-coded 'universal' facial expressions of emotion.

4.1 Limitations of FACS-coded 'Universal' Facial Expression Stimuli

Currently, FACS-coded 'universal' facial expressions of emotion[9] are the most widely used and accepted form of stimuli for emotion research (e.g., Adolphs, Spezio, Parlier, & Piven, 2008; Furl, van Rijsbergen, Treves, Friston, & Dolan, 2007; J. S. Morris, et al., 1998; Phelps,

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

Ling, & Carrasco, 2006; P.G. Schyns, et al., 2007; Philippe G. Schyns, et al., 2009; M. L. Smith, et al., 2005; Vuilleumier, Richardson, Armony, Driver, & Dolan, 2004). They are preferred for three reasons:

a) rigorously controlled to eliminate irrelevant and potentially confounding variations (e.g., orientation, background colour, lighting, gender distribution and so forth)
b) 'universal' implying that all 6 facial expressions are free from cultural bias and elicit comparable recognition performance across all cultural groups
c) rigorously controlled to provide "equal emotion-signalling properties across encoder cultures" (Matsumoto, 2002, page 238).

While point (a) is upheld, I will address points (b) and (c) to reveal substantial flaws, which invalidate them as truly universal facial expressions of emotion.

4.1.1 'Universal' Facial Expression Stimuli are Not Universal

Although advertised as 'universal' facial expressions, closer inspection of the recognition literature shows that claims of universality are false. Rather, 'universal' facial expressions consistently elicit significant differences in recognition accuracy across diverse cultural groups (e.g., Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi, et al., 2005). For example, 'fear' and 'disgust' consistently elicit lower recognition performance amongst EA compared to WC observers (e.g., Biehl, et al., 1997; Chan, 1985; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989). With such consistent differences in recognition performance across cultures, why are these facial expression stimuli claimed to be 'universal?' As mentioned previously in the *Introduction*, false claims of universality are based on faulty criteria. I will re-iterate the flaws in the criteria used so far as they reveal the extent to which 'universal' facial expression stimuli are invalidated as truly pan cultural signals of emotion.

4.1.1.1. Criteria Used to Demonstrate 'Universal Recognition' is Flawed

As discussed previously, the literature has so far considered 'universal recognition' as "…demonstrated by two criteria: first, that [recognition accuracy is] significantly greater than chance; and second, that the percentage [is] greater than an arbitrary level, usually 70%, across all cultures" (Matsumoto, 1992, pg. 72). Such criteria present two significant problems.

a) Insensitive Criteria Generates Type II errors

Such criteria are too insensitive to detect any significant differences in recognition performance, thus masking systematic cultural differences reported in all such cross-cultural recognition studies (e.g., Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi, et al., 2005). As a result, so-called 'universal' facial expression stimuli would be incorrectly considered as eliciting comparable (i.e., no significant differences) in recognition performance. When more appropriate criteria are applied (e.g., statistically comparable recognition performance across cultures), the six 'universal' facial expression signals (Ekman & Friesen, 1978; Matsumoto & Ekman, 1988) do *not* elicit universal recognition and therefore cannot be considered as universal signals of human emotion.

b) Above Chance Performance Does Not Reflect 'Normal' Human Recognition

Claiming that above chance performance (i.e., 14%-16% accuracy, depending on a 6-AFC or 7-AFC task) demonstrates 'recognition' is completely unreasonable as it by no means reflects ecologically valid, 'normal' levels of human recognition. Indeed, if an observer were to perform at 14% accuracy when categorising any other set of objects (e.g., houses, cars, cats, dogs and so forth), the observer would likely have a serious cognitive deficiency that hinders visual perception and/or recognition. Presuming that none of the observers participating in any of the studies cited above suffered from any relevant cognitive impairment, it is certainly safe to say that the poor recognition performance is due to the invalidity of the stimuli. That is, certain ‘universal’ facial expressions simply do not accurately represent emotion in all cultures and therefore cannot be considered to be universal signals of human emotion.

4.1.2 *‘Universal’ Facial Expressions are Culturally Biased*

Although certain cultural groups fail to accurately recognize some so-called ‘universal’ facial expressions, WC observers consistently achieve normal recognition (typically >85%) for all 6 facial expressions (e.g., Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi, et al., 2005), demonstrating that ‘universal’ facial expressions are in fact largely biased towards WC signals. Indeed, the inherent cultural bias is quite understandable when one considers their historical development of FACS-coded ‘universal’ facial expressions. In developing ‘universal’ facial expressions, early cross-cultural recognition studies (e.g., Ekman, et al., 1969) selected stimuli based on their conformity to Facial Action Scoring Technique (FAST, since abandoned and replaced with FACS) criteria (Ekman, Friesen, & Tomkins, 1971). Specifically, FAST/FACS criteria specify the pattern of functionally anatomical facial muscle movement (called Action Units or AUs) associated with each of the 6 ‘basic’ facial expressions of emotion. Such criteria are listed in the Emotion FACS (EMFACS; Ekman & Friesen, 1982) ‘dictionary’ for the purposes of accurately identifying specific facial expressions (see also Ekman, 1972; Ekman & Friesen, 1975, 1978).

Yet, the FAST/FACS criteria suffer from a major flaw – the prescribed patterns of muscle contractions for each facial expression were based only on WC posed facial expressions recognized (i.e., at least 70% accuracy) by WC observers. Without any cross-cultural representation of facial expressions, FAST/FACS criteria represent WC biased facial expressions. Despite the clear methodological flaw, FAST/FACS criteria were listed in the Emotion FACS (EMFACS; Ekman & Friesen, 1982) dictionary and used to create sets of FACS-coded ‘universal’ facial expressions commonly used in research today.

As demonstrated above, not only are FACS-coded ‘universal’ facial expressions inherently culturally biased in terms of their patterns of facial muscle activation, their supposed ‘universality’ is based only on statistically and theoretically inappropriate criteria. Thus, contrary to popular belief, FACS-coded ‘universal’ facial expressions are not devoid of culture-specific expressive signals (Elfenbein & N. Ambady, 2002; Elfenbein, Beaupre, et al., 2007); they are, in fact, culturally biased WC-specific facial expressions.

4.1.3 ‘Universal’ Facial Expressions Do not Provide Equal Signalling Properties Across Cultures

As described above, FACS-coded facial expressions of emotion are rigorously controlled in terms of their signal properties. Specifically, each image within a facial expression category is represented using the same pattern of facial muscle activation, as prescribed by FACS criteria (Ekman & Friesen, 1975). Controlling the signal properties of the facial expressions usefully eradicates any irrelevant signal variations, thus providing signal equality. However, prescription of WC biased facial expression patterns (via FACS coding criteria) introduces a culture-specific perceptual inequality to the stimulus set, as demonstrated by the reported cultural differences in recognition performance. That is, although FACS-coded ‘universal’ facial expressions are *physically* equivalent, they are not *perceptually* equivalent across culturally different observer groups. Therefore, claims that FACS-coded ‘universal’ facial expressions provide “equal emotion-signalling properties across encoder cultures” (Matsumoto, 2002, pg 238) is unfounded.

This is an important point that has not so far been acknowledged by the current emotion literature – culture (i.e., conceptual knowledge) shapes perceptual experience, as demonstrated in the *General Introduction* with examples such as the Checker-shadow Illusion (Adelson, 1995) and culture-specific perceptual distortions of the colour spectrum (Davidoff, et al., 1999).

4.1.4. *‘Universal’ Facial Expressions are Not ‘Pure’*

The standardization of 'universal' facial expressions using FACS-coding was intended to eliminate any cultural influences (e.g., operation of display rules) and to create pan cultural and 'pure' facial expressions of emotion (i.e., those generated by the Facial Affect Programme). Yet, in the absence of a direct demonstration that such facial expressions are indeed generated by the proposed Facial affect Programme, it is likely that each 'universal' facial expression is not 'pure,' but in fact contaminated. Here, I will consider 2 potential sources of contamination – cultural and functional.

4.1.4.1 Cultural Contamination

The facial expressions used to create 'universal' facial expressions and the corresponding prescriptive FACS-code criteria were either 'spontaneous' or simulated by WC posers. In both cases, it is possible that the resulting facial expression could be contaminated with culture-specific facial signals. When instructed to simulate a facial expression, posers are likely to have generated facial expressions typically used for social communication, rather than those which are innate and biological. Indeed, in most cases, posers were instructed to display a facial expression that would accurately communicate their emotions to their friends or family (e.g., Elfenbein, Beaupre, et al., 2007). Given that display rules are likely to be ingrained to the point of becoming habitual, it would seem unlikely that many observers have been exposed to reflexive facial expressions or are particularly practiced at simulating them. Thus, accurate simulation of an involuntary 'pure' facial expression (i.e., those generated by the innate Facial Affect Programme) seems implausible and is certainly not verified anywhere in the literature. Similarly, so-called 'spontaneous' facial expressions may still reflect culture-specific display rules, given proposals that such learned expression management techniques are habitual and therefore fast acting to the point where initial facial reactions may be completely masked (Ekman, 1972). Thus, any simulated or spontaneously generated facial expressions are likely to be contaminated by the top-down influence of culture, such as display rules or 'dialects.' Indeed, standardized, cultural ‘accents’ are perceptible in ‘universal’ facial expressions as shown by Marsh and colleagues (Marsh, et al., 2003). However, the authors did not isolate the information that is culturally modulated (i.e., the face information that observers use to discriminate USA and Japanese nationals) and it remains as yet unknown which face information is diagnostic of USA versus Japanese nationality.

4.1.4.2 Functional Contamination

Facial expressions are generated under a variety of conditions to perform different functions – they can be a spontaneous, physiological response to an external stimulus (e.g., when one “gets a fright”), or they can be used during social interaction to communicate emotion where cultural/social rules can have a modulatory influence.

Spontaneous Facial Expressions: Spontaneous facial expressions are considered to be a reflexive, physiological response, which are the vestiges of a protective reflex (Andrew, 1963; Susskind, et al., 2008). These involuntary, uncontaminated facial expressions are therefore likely to be innate and universal. Truly spontaneous facial expressions can only be obtained under conditions whereby the stimulus is strong enough to evoke an uninhibited facial expression (e.g., smelling very strong sulphur) and where no social factors influence expressive behaviour. While many anthropologists claimed to have captured spontaneous facial expressions, most examples were typically observed within social situations (e.g., funerals, child rearing, greetings and so forth). Such facial expressions are likely to reflect facial expressions used for social communication rather than those that are possibly innate and universal (i.e., reflexive facial expressions). To capture the appearance of truly reflexive facial expressions, several early studies induced emotion via internal generation (Feleky, 1924) or external provocation (e.g., Landis, 1924). However, such methods are likely to give rise to inconsistent results as it is unclear as to whether the stimuli evoked the same emotional experience across all observers (e.g., decapitating a rat could cause ‘fear’ in one person and ‘disgust’ in another) and whether the emotion experienced is singular ('pure') or a combination of emotions (i.e., emotion "blends" Ekman, 1972). With no objective method of validation whether a facial expression produced is entirely reflexive, or representative of a single emotion, a demonstration of 'non-social,' innate facial expressions remains elusive. The ability to show facial expressions directly generated by a Facial Affect Programme remains a challenge for future multi-disciplinary investigation with neuroscientists (e.g., measure reflexive facial response at the brain level).

Social Facial Expressions: Social facial expressions are the voluntary activation of facial muscles used to deliberately communicate emotion. For example, a smile is typically used when greeting someone to indicate the opportunity for positive interaction. Given the powerful top-down influence on the production of social facial expressions and the likely shaping of social convention, it is entirely likely that such facial expressions differ significantly from reflexive facial expressions. It is also important to point out that while many studies on the recognition of facial expressions used posed 'social' facial expressions, the posed facial expression is likely to be an iconic representation rather than an ecologically valid reflection of facial expressions used during social interaction.

Here, I have identified a potential source of difference in the nature of facial expression signals in general – facial expressions can either be the result of a reflexive physiological reaction (e.g., smelling a very pungent odor) or produced under voluntary control during social situations to communicate internal states.

Clearly, while studies focusing on the *production* of facial expressions (e.g., Feleky, 1914; Landis, 1924) were examining the reflexive, physiological manifestations of internal emotional states, *recognition* studies more likely examined the facial expression signals used for emotion communication. Given that facial expressions have both a social (and therefore cultural) and physiological component, it is important to clearly separate out and examine each independently to more accurately represent facial expressions, as expressed by LaBarre in early works: “In the language of gesture all over the world there are varying mixtures of the physiologically conditioned response and the purely cultural one, and it is frequently difficult to analyze out and segregate the two” (Labarre, 1947, pg. 57).

Finally, it is important to highlight a significant methodological flaw in the creation of ‘universal’ facial expressions, which questions whether such facial expressions accurately represent ‘pure’ facial expressions (either as social or reflexive). ‘Universal’ facial expressions are based on stimuli that “…conveyed a single specific emotion to observers…”(Ekman, et al., 1971, pg 52). However, by using an AFC format, observers were restricted to only giving a single specific response (i.e., ‘happy,’ ‘sad,’ ‘angry’), even though they may have considered the face to represent a blended emotion (e.g., ‘angry’ and ‘sad’). It is unsurprising that the authors concluded the images “conveyed a single specific emotion,” but the claim is simply unsubstantiated.

4.2 Implications of Using Current FACS-coded ‘Universal’ Stimuli in Research

As demonstrated above, both the prescribed FACS criteria for each ‘universal’ facial expression and the stimuli on which they are based (e.g., JACFEE, POFA and so forth) do not represent ‘universal’ signals of human emotion. Rather they represent culturally biased WC facial expression signals. Yet, this inherent bias is largely unknown, with such stimuli sets (e.g., JACFEE, POFA and so forth) and FACS criteria (e.g., Ekman & Friesen, 1975, 1982) continuing to be used in cross-cultural emotional research (e.g., Matsumoto & Willingham, 2006, 2009). Here, I will point out some of the negative implications of using these stimulus sets and the FACS criteria using examples from published work.

4.2.1 Application of Biased FACS Criteria

Some recent studies examining cross-cultural differences/universality in facial expressions have focused more on spontaneous rather than posed facial expressions of emotion as they represent more ecologically valid examples of emotional expression. For example, Matsumoto & Willingham (2009) captured the facial expression of competing sportsmen during the announcement of results at the 2004 Olympic Games and compared displays of facial expressions across cultural groups (Matsumoto & Willingham, 2006). Although obtaining an impressively wide variety of naturally occurring facial expression images (~21,000 images), the authors only selected images that conformed to FACS-criteria (Ekman & Friesen, 1982), therefore systematically biasing their dataset. As a result, any cultural variation in facial expression signals would have been eliminated. Not surprisingly, the authors conclude that people from all cultures express emotion in the same way and that facial expressions are indeed 'universal' (see also Matsumoto & Willingham, 2009).

As demonstrated above, the use of 'cookie-cutter' methods to examine the complexities of facial expression signals is just too crude, especially when the 'cookie-cutter' is fundamentally flawed (i.e., strongly biased). It is also important to point out that the EMFACS (and therefore FACS criteria) lack peer review and should not be used for scientific purposes as is the case currently (e.g., Berenbaum & Oltmanns, 1992; Ekman, Matsumoto, & Friesen, 1997; Keltner, Moffitt, & Stouthamer-Loeber, 1995; Matsumoto, Haan, Yabrove, Theodorou, & Carney, 1986; Matsumoto & Willingham, 2006; Matsumoto & Willingham, 2009; Rosenberg & Ekman, 1994; Rosenberg, Ekman, & Blumenthal, 1998; Rosenberg, et al., 2001).

4.2.2. Use of Biased 'Universal' Facial Expression Stimuli

4.2.2.1 Facial Expression Processing

Using the term 'universal' to describe a facial expression stimulus set reasonably infers that the stimuli elicit comparable recognition performance across all observer groups. Yet, this is entirely unsubstantiated by the literature – 'universal' facial expressions do *not* elicit universal recognition in the traditionally understood sense (see points 5.1.1.1. a-b above). Given that 'universal' facial expression stimulus sets don't do what it says on the tin, use of the term 'universal' is misleading to researchers and could result in significant methodological problems.

For example, Moriguchi et al., (2005) used a 'universal' stimulus set in good faith to examine cultural differences in the brain's response to 'fear' ful faces between WC and EA observers (Moriguchi, et al., 2005). However, the EA observers systematically categorised 'fear' facial expressions as 'surprise,' as predicted by previous data (Matsumoto, 1989). Consequently, the authors were unable to obtain a meaningful brain response to 'fear' ful faces amongst the EA group.

The above example is a cogent demonstration that current so-called 'universal' facial expressions of emotion cannot be used in (most)[10]cross-cultural research where the aim is to examine the influence of culture upon facial expression processing *per se*. Rather, current 'universal' facial expressions (e.g., JACFEE, POFA, KDEF, etc.) only represent one cultural group (WC). At present, there is no equivalent stimulus set that accurately represents any other culture, thus limiting scientific progression in this area (i.e., how people of different cultures process facial expressions of emotion).

4.2.2.2 Facial Expression Processing In a Cross-Cultural Design

Another area of research limited (or potentially biased) by the current stimulus set is in understanding the complexities of cross-cultural communication of emotion. For example, during cross-cultural communication, do observers decode and interpret facial expressions in the same way as during intra-cultural communication? This question is loosely related to the in-group advantage theory, which proposes that observers more accurately recognize facial expressions displayed by members of their own culture compared to those displayed by other-culture members (Elfenbein & N. Ambady, 2002). While the in-group advantage theory and related ideas have been actively discussed in the literature (Elfenbein & N. Ambady, 2002; H. A.

[10] It is important to point out here that my use of the 'universal' JACFEE facial expression stimulus set in Experiment 1 is entirely appropriate given the research question: Experiment 1 investigated the origins of the EA recognition deficit for *'universal'* facial expressions (i.e., those depicted by the JACFEE stimulus set) as reported in the literature (e.g., Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi, et al., 2005).

Elfenbein & N. Ambady, 2002; Matsumoto, 2002), it is not yet clear which information could potentially give rise to the proposed in-group advantage – that is, which information ought to indicate group affiliation. Two factors should reasonably be considered as potential identifiers of 'in-group' status – a (controlled) culture-specific feature (e.g., skin colour, facial characteristics, hairstyle, clothing etc.) or, as the authors suggest (see Elfenbein & N. Ambady, 2002), culture-specific facial expressions (i.e., cultural 'accents').

In both cases, a fully balanced design would be required such that each cultural observer group would be exposed to both the cultural identifiers. To illustrate the importance of using a balanced design, consider the following unbalanced design used to examine whether culture-specific facial expressions generate differences in facial expression decoding across observer groups: 2 observer groups (WC and EA) and 1 set of culturally valid facial expressions (WC). Any difference found (i.e., same-culture facial expressions – WC observers decoding WC facial expressions – are decoded differently from other-culture facial expressions – EA observers decoding WC facial expressions) could be due to a culture-specific decoding strategy (Jack, et al., 2009), and not related to cross-cultural communication *per se*. Let's now consider the alternative unbalanced design: 1 observer group (WC) X 2 sets of culturally valid facial expressions (EA). Similarly, any difference here (i.e., same- versus other-culture facial expressions are decoded differently) could be due to a culture-specific (i.e., WC) decoding strategy that is not generalizable to any other cultural group. Thus, in order to truly understand the complexities of cross-cultural communication, a fully balanced design is necessary.

4.2.2.3 The Influence of Race on Facial Expression Decoding

Now let's examine each potentially relevant factor in turn and assess whether current facial expression stimuli can be used to adequately address the question. First, does the perception of 'in-group' versus 'out-group' affiliation influence emotion communication as measured by the decoding and interpretation of facial expressions? Specifically, do WC observers decode and interpret facial expressions in the same way when they are displayed by WC compared to EA posers (and vice versa, this adhering to the necessary balanced design). To examine this question, it is important to first isolate the factor in question – the information that reliably indicates 'in-group' versus 'out-group,' in this case the race of face. While race of face is manipulated as part of the experimental design (i.e., half of the stimuli are EA faces), all other information must be controlled, as clearly stated by Matsumoto "If stimuli portraying emotion expressed by people of two different cultural groups are to be judged by members of both of those groups, then the characteristics of the stimuli specific to the emotion message must be exactly equivalent between the two expresser cultures, whereas only the characteristics related to cultural identification should vary" (Matsumoto, 2002, pg. 237). Thus, the facial expressions displayed by both the WC and EA posers should be equally recognizable by both WC and EA observers when no cultural affiliation is indicated. As a result, we can ascertain whether perception of 'in-group' versus 'out-group' member affiliation (i.e., race/ethnicity) generates a perceptual change that influences the decoding and interpretation of facial expressions.

Is there is a stimulus set that can adequately address this question? The short answers is no – there is, as yet, no stimulus set that elicits comparable recognition performance across all cultural groups. Indeed, the only stimulus set specifically designed to examine the influence of ethnicity/race on facial expression decoding (the JACFEE stimulus database) cannot provide a balanced design as it does not provide "equal emotion-signalling properties across observer cultures," as is claimed (Matsumoto, 2002, pg 238). Specifically, while the JACFEE stimulus set is rigorously controlled for gender, race (EA and WC) and the *physical* facial expression signals (each facial expression is displayed using exactly the same pattern of facial muscle activation), the facial expression signals are unbalanced as they only represent one cultural group (i.e., WC)[11]. That is, the characteristics of the stimuli are *not* exactly equivalent to both members of the observer groups – they are, in fact, perceptually different. Thus, any attempt to examine the influence on racial/ethnic identity on facial expression recognition using such stimuli would be confounded by the *perceptual* inequalities of the stimuli across cultural groups. It is important to point out here that the reported cross-cultural differences in recognition performance elicited by the 'universal' JACFEE facial expressions are not due to the perception of 'in-group' versus 'out-group' (i.e., racial/ethnic) affiliation but is due to the fact that JACFEE facial expressions represent WC biased facial expressions (e.g., Jack, et al., 2009).

As demonstrated above, there is as yet, no stimulus set that can be used to adequately examine whether perceived 'in-group' versus 'out-group' affiliation (as defined by race/ethnicity) influences the decoding and interpretations of facial expressions as current stimuli can only offer a WC biased, unbalanced design.

4.2.2.4 Decoding Culture-specific Facial Expressions

Let us now turn to the second factor relevant for understanding cross-cultural communication – How do observers of different cultures decode and interpret 'in-group' versus 'out-group' facial expressions (i.e., is there an in-group advantage)? First, it is important to point out that this question is entirely justified given the overwhelming amount of behavioural data showing that facial expressions (as represented by FACS-coded facial expression) are not universal, supporting views of cultural specificity in facial expression signals (H. A. Elfenbein & N. Ambady, 2002). Furthermore, as reported in Experiment 2, I have provided the first direct demonstration of cultural specificity in facial expression signals, thus justifying the rationale for asking such a research question.

[11] My use of the JACFEE stimulus set in Experiment 1 did not create an unbalanced design as the aim was not to examine cultural differences in the decoding of (culturally valid) facial expressions, but instead I investigated the origins of the EA recognition deficit for *'universal'* facial expressions (i.e., those depicted by the JACFEE stimulus set) as reported in the literature (e.g., Biehl, et al., 1997; Chan, 1985; Ekman, et al., 1987; Ekman, et al., 1969; Jack, et al., 2009; Matsumoto, 1992; Matsumoto & Ekman, 1989; Moriguchi, et al., 2005).

To address the above question using an appropriately balanced design, both observer groups would be exposed to both sets of culturally valid facial expression stimuli. For example, WC and EA observers would decode and interpret both WC and EA facial expressions. Is there is a stimulus set that can adequately address this question? Again, the answer is no. As pointed out above, with only WC validated facial expression stimuli currently available and with no equivalent stimulus set that accurately represents any other culture, a balanced design is beyond reach. As a result, it remains unknown as to whether observers are significantly better at judging facial expressions from their own culture (i.e., the in-group advantage). At this point, it is worth pointing out that Elfenbein and colleagues (Elfenbein, Beaupre, et al., 2007) recently investigated the in-group advantage using a balanced design using 2 sets of culture-specific facial expressions (Québecois and Gabonese). Specifically, the authors examined whether the posed facial expressions contained cultural 'dialects' as measured by differences in AUs and also whether an in-group advantage was demonstrated by a cross-cultural recognition task. However, neither the Québecois nor the Gabonese facial expression images can be considered to be culturally representative, as demonstrated by the particularly low recognition accuracy reported in the paper. For example, the mean recognition accuracy of Québecois observers categorising Québecois posed facial expressions of 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad' was as low as 56%, 34%, 54%, 47% and 39%, respectively. Similarly, the mean recognition accuracy of Gabonese observers categorising Gabonese posed facial expressions of 'surprise' ,' 'fear,' 'disgust,' 'anger' and 'sad' were as low as 50%, 18%, 35%, 33% and 38%, respectively. Furthermore, the stimuli suffer from a number of stimulus control inadequacies such as size of face, lighting, idiosyncratic hairstyles and so forth (see page 137 in Elfenbein, Beaupre, et al., 2007 for examples), which can lead to spurious differences. Consequently, such stimuli cannot be used to adequately examine a) whether ecologically valid facial expressions contain culture-specific 'dialects' or b) if the in-group advantage is a legitimate psychological phenomenon within cross-cultural communication of emotion.

4.2.2.5 Interaction of Race and Culture-specific Facial Expression

In the context of comparing culturally diverse group, racial characteristics (e.g., skin colour, facial morphology) are an inevitable perceptual indicator of specific cultural affiliations[12]. For example, when presented with an EA face, the observer is likely to assume that the person is of an Eastern culture, based on probabilistic reasoning. Thus, racial characteristics are an important point for consideration and empirical inclusion when examining the cross-cultural interactions. For example, WC-specific facial expressions are likely to be more ecologically valid and representative if displayed by a racially congruent individual (i.e., a white Caucasian). Indeed, a relevant empirical question is how these two distinct cultural identifiers (i.e., racial characteristics and culture-specific facial expressions) influence socially relevant categorizations. For example, is facial expression decoding modulated by the cultural incongruence of facial expression and racial characteristics (e.g., a WC poser displaying an EA-specific facial expression)? Similarly, is race categorization (as measured by reaction time; see R. Caldara, Rossion, Bovet, & Hauert, 2004; Levin, 1996; Valentine & Endo, 1992) modulated by the cultural incongruence of the facial expressions displayed? For example, the Other-Race Effect (ORE) – characterized by faster race categorization of other- compared to same-race faces – could be dampened by culturally incongruent (i.e., same culture) facial expressions by influencing the perception of group affiliation. In short, such questions address the extent to which certain socially relevant information which acts as a cultural identifier exerts a powerful influence on the perceptual decoding of emotional signals and on social interaction behaviours generally.

[12] Clearly, this depends on the research question. For example, if examining how Rangers and Celtic fans interact, racial characteristics are unlikely to be a concern as it is unlikely that either group possesses perceptually distinct facial characteristics diagnostic of their cultural affiliation. Rather, cultural affiliation would be indicted by an external symbol, such as football colours.

4.3 Future Work

Here, I have highlighted the limitations of the facial expression stimuli currently available, namely those which are FACS-coded and advertised as 'universal.' Specifically, I have demonstrated that it is entirely inappropriate and misleading to claim that FACS-coded facial expressions (the *only* accepted standardized stimuli set in research) are 'universal.' Consequently, using such stimuli to address certain research questions inevitably introduces methodological flaws by unbalancing the experimental design. Thus, certain relevant cross-cultural questions cannot be adequately addressed with such biased stimuli, requiring significant improvements in the stimulus resources available for research. To address this gap in resources, I will now outline the specifications and developmental direction required to provide adequate stimulus sets for future cross-cultural research and detail future and current projects aiming to address this gap.

4.3.1 Improving Stimuli for Future Research

As discussed previously, current facial expression stimuli are considered to be 'universal' if a certain statistically and theoretically flawed criterion is met – above chance recognition performance (>14% accuracy). Clearly, such criterion neither demonstrates 'normal' human recognition nor is sensitive enough to detect significant differences in recognition performance across observer groups. Given that the vast majority of the emotion literature accepts this criterion as a reliable indicator of 'universal recognition,' it is imperative that such pivotal concepts are explicitly re-established within the literature to improve experimental design, data interpretation and future directions. Furthermore, such terms are the tools by which we communicate complex concepts, thus a shared understanding of these terms will help avoid confusion and miscommunication in the future. To re-iterate the magnitude of the current situation, I refer to my previous example (page 86) where Moriguchi and colleagues (Moriguchi, et al., 2005) used ‘universal’ facial expressions in good faith only to later suffer severe methodological problems and ultimately data loss at the hands of false advertizing.

As described, current facial expression stimuli do not meet the criteria necessary to adequately conduct cross-cultural research as they only accurately represent facial expressions one cultural group (WC), as measured by recognition accuracy. As a result, with stimulus validity limited to WC displays of emotion, knowledge of different cultural groups is suspended (Henrich, et al., 2010). To create a truly universal facial expression stimulus set, it is essential that the facial expression signals depicting each of the 6 ‘basic’ facial expressions (i.e., ‘happy,’ ‘surprise,’ ‘fear,’ ‘disgust,’ ‘anger’ and ‘sad’) are recognized with statistically comparable and ecologically valid levels of accuracy (i.e., >75% accuracy). Two possible options are available – 1) creating a single uniform set of facial expression signals (i.e., 6 facial expression signals), or 2) separate culture-specific subsets of facial expression signals (i.e., 6 facial expressions per cultural group), both of which meet the above recognition criterion (>75% accuracy). In both cases, the facial expression stimuli would provide perceptual stimulus equivalence across observer cultures, allowing the necessary balanced design. To examine the empirical suitability of both stimulus sets, let’s consider each in turn.

4.3.1.1 Culture-specific Subsets of Facial Expression Signals

By creating culture-specific facial expression stimuli, several cross-cultural research questions could be addressed. For example, examining the in-group advantage whereby recognition performance of each observer group decoding the facial expressions of their own versus other cultural groups would be tested and compared. Similarly, to better understand the perceptual processes underlying cross-cultural communication, eye tracking technology could be used to investigate the decoding of own versus other cultural facial expressions. Furthermore, by direct comparison of each AU, the facial information unique to each cultural group could be identified, revealing specifically how facial expressions differ across cultures. Similarly, using the *Bubbles* technique (Gosselin & Schyns, 2001) – which isolates the information required for categorization – the expressive features used by each culture to accurately recognize facial expressions could be isolated. Together, these newly accessible investigations would yield novel results in the field of culture and emotion, elevating knowledge of cross-cultural communication of emotion.

Future Work 1: *Dynamic Facial Expressions of Emotion – 4D Stimuli and the Future*

To address this gap in resources, I will create 2 subsets of culture-specific facial expressions of emotion using the same RC technique used in Experiment 2. Specifically, I will reconstruct 4D, culture-specific representations of the 6 'basic' facial expressions of emotion to improve upon static (2/3D) images of facial expressions of emotion. Tomkins and McCarter highlight this requirement in early works: "The photograph congeals this motion into a still which is never entirely adequate as a recognizable affective response" (Tomkins & McCarter, 1964, pg. 126).

To achieve this, WC and EA observers will be presented with dynamic face stimuli where each AU (50 in total) will be randomly activated on 6 parameters (i.e., peak intensity, peak latency, onset latency, offset latency, acceleration, and deceleration). After viewing the dynamic display, observers will indicate the perceived relative contribution of the 6 'basic' facial expressions of emotion using a sliding scale (0-5). Using a multi-choice task allows a more accurate assessment of the presented information by the observer, thus avoiding the limitations of using AFC tasks, as described previously. As a result, we can examine whether there are specific emotion blends frequently represented by either culture. Each culture-specific representation for each of the 6 facial expressions will then be reconstructed and can then later used to create full colour, 4D facial expression stimuli. For example, the WC representation of 'disgust' (i.e., the dynamic facial muscle pattern) can be married with the facial texture (e.g., skin, eye colour) of an EA female identity. Several WC and EA textures (equally distributed for gender) will be gathered to create fully interchangeable stimulus sets for future research projects.

While culture-specific subsets of facial expressions would be appropriate for certain research questions (e.g., how do observers of different cultures decode and interpret culture-specific facial expressions?), the inherent physical differences in the signals (e.g., EA 'fear' versus WC 'fear') would exclude them from use for other research questions. To illustrate, consider the following research question asked previously by Moriguchi and colleagues - do WC and EA observers process 'fear' ful faces in the same way as measured by fMRI?' While use of culture-specific facial expression signals would ensure that both observer groups were processing a 'fear' ful face, any physical difference between the 'fear' ful faces could give rise to a potential confound in the data. That is, significant differences in brain response could be related to differences between the physical signals rather than a reflection of cognitive differences the experiment intends to examine.

4.3.1.2 Single Uniform Set of Facial Expressions

To satisfy the relevant methodological requirement that facial expressions stimuli are both physically equivalent (each facial expression is displayed using exactly the same pattern of facial muscle activation) and perceptually equivalent across observer groups, a single uniform set of facial expression signals that are recognized with comparable accuracy across all cultures would be required. To do this, the truly universal facial expression information must be identified and isolated to create a single uniform stimulus set. Indeed, non-random (i.e., above chance recognition) responses to 'universal' facial expressions by diverse cultural groups demonstrate that 'universal' facial expressions may contain *elements* of universal signals of emotion. Indeed, it is quite possible that truly universal signals of emotion are present in many culture-specific facial expressions. For example, consider the following culture-specific facial expression of the Oryia women in Bhubaneswar, India. Shweder reports a commonly used facial expression “in which the tongue extends out and downward and is bitten between the teeth, the eyebrows rise, and the eyes widen, bulge, and cross” (Shweder, 1991, pg. 246). Based on the available information, we might reasonably conclude that the woman is frightened or ‘surprise’ d, on account of the raised eyebrows and widened eyes. In fact, we would be correct – this particular facial expression represents ‘surprise’ /embarrassment/fear. Thus, to correctly interpret this unfamiliar facial expression, the ‘universal’ elements have been identified and those which are perhaps inexplicable and culture-specific (i.e., tongue protrusion, crossing of the eyes) have been ignored.

In acknowledging the involvement of culture-specific factors in modulating the display of facial expressions (i.e., display rules), it has been stated that “…the sources of cultural variability are so many that it is exceedingly difficult to observe the common facial expressions of emotion across cultures” (Ekman, 1972, pg 234). However, although claiming to have isolated and demonstrated the ‘basic’ set of ‘universal’ facial expressions (e.g., Ekman & Friesen, 1975; Matsumoto & Ekman, 1988), no attempt has been made, as yet, to examine the signal properties of the facial expressions to determine which are universal across all groups and those which are culture-specific (but see Marsh, et al., 2003 for cultural 'accents'). Thus, it is important to isolate both the cultural and universal signals of emotion to understand exactly how culture has modified the universal signals of human emotion. To address this, I will use complementary statistical image processing tools to examine the dynamic expressive facial signals in culture-specific facial expressions of emotion to identify any such universal emotional signals. Similarly, I will use the *Bubbles* technique to isolate the expressive features used for accurate facial expression categorization in WC and EA groups to determine culture-specific and universal information use.

Future work 2: Mapping The Conceptual Landscapes of Diverse Cultures

Culture represents an intricate system of values, knowledge and beliefs, which correspond to cultural variability in language terms used to express cultural concepts. Indeed, Wilhelm von Humboldt described language as "the expression of the spirit of a nation" (von Humboldt, 1836/1999). Culture-specific semantic organization reflecting conceptual differences across cultures and could be associated with cognitive and perceptual differences. For example, Roberson and colleagues showed that perceptual colour category boundaries are influenced by cultural linguistic systems (Roberson, Davies, & Davidoff, 2000). Cultural differences in the decoding and interpretation of facial expressions of emotion could also be influenced by culture-specific conceptions of emotion.

Taking inspiration from Davidoff's colour study described previously (Davidoff, et al., 1999), I will aim to map the conceptual landscape of emotion, specifically facial expressions, in two distinct cultural groups – WC and EA. To do this, I will use data obtained from *Future work 1* where WC and EA observers will categorise all[13] possible combinations of facial muscle movements (i.e., all possible facial behaviours). As a result, I can reveal where the emotion boundaries lie in range of facial expressions and whether such boundaries are common across all cultures. Furthermore, I have taken into consideration that the 6 so-called 'basic' emotions (i.e., 'happy,' 'surprise,' 'fear,' 'disgust,' 'anger' and 'sad') may not necessarily be universally agreed. For example, Roberson and colleagues showed that the focal colours (specific colours centered on 'pink,' 'yellow,' 'orange,' 'red,' 'green,' 'blue,' and 'purple') widely believed to universal are not shared by all observers (Roberson, et al., 2000). Given how variant cultural concepts of emotion are in terms of antecedents etc., (e.g., Mesquita & Frijda, 1992) it is quite likely that emotion boundaries and basic categories differ across cultures, as argued by some (Russell, 1994). Therefore, to develop a richer understanding of the cultural effects on

[13] The total number of possible combinations represents a combinatorial explosion (50 AUs with 6 parameters adjusted on a continuous scale). To manage the design intelligently, I will ensure that the combinations of AUs and parameter values represent a robust selection across all possible combinations.

perception, specifically related to emotion, it is important to map the conceptual landscapes of diverse cultures.

On a broader note, examining cultural specificity of 'emotion' is more than just the recognition of facial expressions. 'Emotion' encompasses a wide range of dimensions that relate to emotional experience whereby the display of a facial expression rests under the dimension of 'emotional behaviour,' as does physiological responses such as heart rate and perspiration. Indeed, recent research documents the cultural specificity of emotional experience and linguistic expressions (Fiske et al., 1998; Harre, 1986; Markus & Kitayama, 1991; Mesquita & Frijda, 1992; Mesquita et al., 1997; Scherer & Wallbott, 1994). Yet, direct demonstrations of the characteristics and dimensions of culture-specific internal concepts remain elusive. To truly understand cross-cultural communication of emotion, it is important to elucidate each conceptual dimension, mapping the culture-specific landscape of the concept 'emotion' using objective methods.

5. Summary Conclusion

Although facial expressions may well have biological origins, those roots are as deep as those which gave us tail bones, goose bumps, wisdom teeth and 'third eyes' (Darwin, 1999/1872). In our newly interconnected world, now is the time to turn more attention towards how thousands of years of culture have shaped the basic, biological skills of facial expression transmission and decoding. Otherwise, when it comes to communicating negative emotions across cultures, Easterners and Westerners will continue to find themselves lost in translation. Importantly, while not denying the biological or evolutionary origins of facial expressions or the existence of universal signals of human emotion, I have illustrated that truly universal facial expression signals remain unknown. As a result, current research remains limited by the substandard tools available. I will address this gap in resources in subsequent work and use the resulting stimuli to continue to advance knowledge in the field of culture and emotion.

6. Bibliography

Lorenz, K. (1903/1989). *Evolution and Modification of Behaviour*. London: Methuen (1966).

Darwin, C. (1999/1872). *The Expression of the Emotions in Man and Animals* (3rd ed.). London: Fontana Press.

Ekman, P. (1992). *Emotions Revealed* (2nd ed.). New York: Henry Holt and Co.

Palmer, S. E. (1999). *Vision Science: Photons to Phenomenology*. Cambridge, Mass., MIT Press.

Turnbull, J. (1813). *A Voyage Round the World in the years 1800, 1801, 1802, 1803, and 1804 in which the Author visited the principle Islands in the Pacific ocean and the English settlements of port Jackson and Norfolk island* (Vols.1-3). London.

Wisniewski, E. J & Medin, D. L (1991). Harpoons and long sticks: the interaction of theory and similarity in rule induction. In Ram, A. & Leake, D. B. (Eds.), *Goal-driven Learning*. Cambridge, Mass., MIT Press.

7. References

Adelson, E. H. (1995). The Checker-shadow Illusion: http://web.mit.edu/persci/people/adelson/checkershadow_illusion.html.

Adolphs, R., Spezio, M. L., Parlier, M., & Piven, J. (2008). Distinct Face-Processing Strategies in Parents of Autistic Children. [doi: DOI: 10.1016/j.cub.2008.06.073]. *Current Biology, 18*(14), 1090-1093.

Ahumada, J. A., & Lovell, J. (1971). Stimulus Features in Signal Detection. *The Journal of the Acoustical Society of America, 49*(6B), 1751-1756.

Andrew, R. J. (1963). Evolution of Facial Expression. *Science, 142*, 1034-1041.

Beaupré, M. G., Cheung, N., & Hess, U. (2000). The Montreal Set of Facial Displays of Emotion [Slides]. Montreal, Quebec.

Bell, C. (1844). *The Anatomy and Philosophy of Expression as Connected with the Fine Arts* (3rd ed.). London.

Berenbaum, H., & Oltmanns, T. F. (1992). Emotional experience and expression in schizophrenia and depression. *Journal of Abnormal Psychology, 101*(1), 37-44.

Biehl, M., Matsumoto, D., Ekman, P., Hearn, V., Heider, K., Kudoh, T., et al. (1997). Matsumoto and Ekman's Japanese and Caucasian Facial Expressions of Emotion (JACFEE): Reliability Data and Cross-National Differences. [10.1023/A:1024902500935]. *Journal of Nonverbal Behavior, 21*(1), 3-21.

Blais, C., Jack, R. E., Scheepers, C., Fiset, D., & Caldara, R. (2008). Culture Shapes How We Look at Faces. *PLoS ONE, . 3*(8), e3022.

Briggs, J. (1970). *Never in Anger: Portrait of an Eskimo family.* Cambridge, MA: Harvard University Press.

Buck, R. (1984). *The communication of emotion*. New York: Guilford.

Buzby, D. E. (1924). The Interpretation of Facial Expression. *The American Journal of Psychology, 35*(4), 602-604.

Caldara, R., Rossion, B., Bovet, P., & Hauert, C. A. (2004). Event-related potentials and time course of the 'other-race' face classification advantage. *Neuroreport, 15*(5), 905-910.

Caldara, R., Zhou, X., & Miellet, S. (2010). Putting Culture Under the <italic>‘Spotlight’</italic> Reveals Universal Information Use for Face Recognition. *PLoS ONE, 5*(3), e9708.

Cannon, W. B. (1915). *Bodily changes in Pain, Hunger, Fear and Rage*. New York.

Chan, D. W. (1985). Perception and Judgment of Facial Expressions Among the Chinese. *International Journal of Psychology, 20*(3), 681 - 692.

Chauvin, A., Worsley, K. J., Schyns, P. G., Arguin, M., & Gosselin, F. (2005). Accurate statistical tests for smooth classification images. *Journal of Vision, 5*(9), 659-667.

Darwin, C. (1999/1872). *The Expression of the Emotions in Man and Animals* (3rd ed.). London: Fontana Press.

Davidoff, J., Davies, I., & Roberson, D. (1999). Colour categories in a stone-age tribe. [10.1038/18335]. *Nature, 398*(6724), 203-204.

Davidoff, J., Fonteneau, E., & Goldstein, J. (2008). Cultural Differences in Perception: Observations from a Remote Culture. [doi:10.1163/156853708X358146]. *Journal of Cognition and Culture, 8*, 189-209.

De Valois, K. K., De Valois, R. L., & Yund, E. W. (1979). Responses of striate cortex cells to grating and checkerboard patterns. *The Journal of Physiology, 291*(1), 483-505.

Dimberg, U. (1982). Facial Reactions to Facial Expressions. *Psychophysiology, 19*(6), 643-647.

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious Facial Reactions to Emotional Facial Expressions. *Psychological Science, 11*(1), 86-89.

Duchaine, B., & Nakayama, K. (2006). The Cambridge Face Memory Test: Results for neurologically intact individuals and an investigation of its validity using inverted face stimuli and prosopagnosic participants. [doi: DOI: 10.1016/j.neuropsychologia.2005.07.001]. *Neuropsychologia, 44*(4), 576-585.

Duchenne, G. B. (1862-1990). The mechanisms of human facial expression or an electro-pshysiological analysis of the expression of the emotions. In R. Cuthebertson (Ed.). New York Cambridge University Press.

Ekman, P. (1968). *Research findings on recognition and display of facial behavior in literate and nonliterate cultures.* . Paper presented at the 76th Annual Convention of the American Psychological Association.

Ekman, P. (1972). *Universals and cultural differences in facial expressions of emotion.* . Paper presented at the Nebraska Symposium on Motivation.

Ekman, P. (1992). *Emotions Revealed* (2nd ed.). New York: Henry Holt and Co.

Ekman, P. (1994). Strong evidence for universals in facial expressions: A reply to Russell's mistaken critique. *Psychological Bulletin, 115*(2), 268-287.

Ekman, P., & Friesen, W. V. (1969). The repertoire of nonverbal behavior: Categories, origins, usage, and coding. *Semiotica, 1*, 49-98.

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. [Journal; Peer Reviewed Journal]. *Journal of Personality and Social Psychology, 17*(2), 124-129.

Ekman, P., & Friesen, W. V. (1975). *Unmasking the face: a guide to recognizing emotions from facial clues.* . Englewood Cliffs: Prentice-Hall.

Ekman, P., & Friesen, W. V. (1976). Pictures of Facial Affect. San Francisco, CA.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system*. Palo Alto, CA.

Ekman, P., & Friesen, W. V. (1982). EMFACS. Unpublished manuscript.

Ekman, P., Friesen, W. V., O'Sullivan, M., Chan, A., Diacoyanni-Tarlatzis, I., Heider, K., et al. (1987). Universals and cultural differences in the judgments of facial expressions of emotion. *Journal of Personality and Social Psychology, 53*(4), 712-717.

Ekman, P., Friesen, W. V., & Tomkins, S. S. (1971). Facial Affect Scoring Technique: A First Validity Study. [doi: 10.1515/semi.1971.3.1.37]. *Semiotica, 3*(1), 37-58.

Ekman, P., Lazarus, R. S., Opton, E. T., Friesen, W. V., & Averill, J. R. (1970). Facial Behavior and Stress in Two Cultures. Unpublished manuscript.

Ekman, P., Matsumoto, D., & Friesen, W. V. (1997). Facial expression in affective disorders. In P. Ekman & E. L. Rosenberg (Eds.), *What the face reveals: Basic and applied studies of spontaneous expression using the facial action coding system (FACS)* (pp. 331-341). New York: Oxford University Press.

Ekman, P., Rolls, E. T., Perrett, D. I., & Ellis, H. D. (1992). Facial Expressions of Emotion: An Old Controversy and New Findings [and Discussion]. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences, 335*(1273), 63-69.

Ekman, P., Sorenson, E. R., & Friesen, W. V. (1969). Pan-Cultural Elements in Facial Displays of Emotion. *Science, 164*(3875), 86-88.

Elfenbein, & Ambady, N. (2002). Is there an in-group advantage in emotion recognition? [Journal; Peer Reviewed Journal]. *Psychological Bulletin, 128*(2), 243-249.

Elfenbein, H. A., & Ambady, N. (2002). On the universality and cultural specificity of emotion recognition: A meta-analysis. [Journal; Peer Reviewed Journal]. *Psychological Bulletin, 128*(2), 203-235.

Elfenbein, H. A., & Ambady, N. (2003). Universals and Cultural Differences in Recognizing Emotions. *Current Directions in Psychological Science, 12*(5), 159-164.

Elfenbein, H. A., Beaupre, M., Levesque, M., & Hess, U. (2007). Toward a dialect theory: cultural differences in the expression and recognition of posed facial expressions. *Emotion, 7*(1), 131-146.
Elfenbein, H. A., Beaupré, M., Levesque, M., & Hess, U. (2007). Toward a dialect theory: cultural differences in the expression and recognition of posed facial expressions. *Emotion, 7*(1), 131-146.
Feleky, A. M. (1914). The expression of the emotions. *Psychological Review, 21*(1), 33-41.
Friesen, W. V. (1972). Cultural differences in facial expression in a social situation: An experimental test of the concept of display rules. Unpublished doctoral dissertation. University of California.
Furl, N., van Rijsbergen, N. J., Treves, A., Friston, K. J., & Dolan, R. J. (2007). Experience-dependent coding of facial expression in superior temporal sulcus. *Proceedings of the National Academy of Sciences, 104*(33), 13485-13489.
Goodenough, F. L., & Tinker, M. A. (1931). The relative potency of facial expression and verbal description of stimulus in the judgment of emotion. [doi: DOI: 10.1037/h0071381]. *Journal of Comparative Psychology (1921), 12*(4), 365-370.
Gorer, G. (1935). *Africa dances*. New York.
Gosselin, F., & Schyns, P. G. (2001). Bubbles: a technique to reveal the use of information in recognition tasks. *Vision Research, 41*(17), 2261-2271.
Gosselin, F., & Schyns, P. G. (2003). Superstitious perceptions reveal properties of internal representations. *Psychological Science, 14*(5), 505-509.
Hall, E. (1966). *The Hidden Dimension*. Garden City, NY: Doubleday.
Han, S., & Northoff, G. (2008). Culture-sensitive neural substrates of human cognition: a transcultural neuroimaging approach. *Nature Reviews Neuroscience, 9*(8), 646-654.
Hearn, L. (1894). *Glimpses of Unfamiliar Japan*. New York.
Helmholtz, H. v. (1867/1925). *Treatise on physiological optics* (Vol. 3). New York: Dover publications.
Henle, F. G. J. (1868). *Handbuch der Systematischen Anatomie des Menschen* (Vol. 3rd). Brunswick: Gefasslehre.
Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The Weirdest People in the World? *SSRN eLibrary*.
Hiatt, S. W., Campos, J. J., & Emde, R. N. (1979). Facial Patterning and Infant Emotional Expression: Happiness, Surprise, and Fear. *Child Development, 50*(4), 1020-1035.
Holt, E. B. (1931). *Animal drive and the learning process*. New York.
Ibrahimagić-Šeper, L., Čelebić, A., Petričević, N., & Selimović, E. (2006). Anthropometric differences between males and females in face dimensions and dimensions of central maxillary incisors. *Medicinski Glasnik, 3*(2), 58-62.
Inhelder, B., & Piaget, J. (1958). *The growth of logical thinking from childhood to adolescence.* New York: Basic Books.
Izard, C. E. (1971). *The face of emotion*. New York: Appleton-Century-Crofts.
Jack, R. E., Blais, C., Scheepers, C., Schyns, P. G., & Caldara, R. (2009). Cultural Confusions Show that Facial Expressions Are Not Universal. *Current Biology, 19*(18), 1543-1548.
Jorma, R. (1989). *Stochastic Complexity in Statistical Inquiry Theory*: World Scientific Publishing Co., Inc.
Kelly, D. J., Miellet, S., & Caldara, R. (2010). Culture shapes eye movements for visually homogeneous objects. [Original Research Article]. *Frontiers in Perception Science, 1.*
Keltner, D., Moffitt, T. E., & Stouthamer-Loeber, M. (1995). Facial expressions of emotion and psychopathology in adolescent boys. *Journal of Abnormal Psychology, 104*(4), 644-652.

Kingstone, A. (2009). Taking a real look at social attention. [doi: DOI: 10.1016/j.conb.2009.05.004]. *Current Opinion in Neurobiology, 19*(1), 52-56.
Klein, J. T., Shepherd, S. V., & Platt, M. L. (2009). Social attention and the brain. *Curr Biol, 19*(20), R958-962.
Klineberg, O. (1940). *Social Psychology*. New York: Holt.
Knapp, M. L., & Hall, J. A. (2005). *Nonverbal Communication in Human Interaction*. Belmont, CA: Wadsworth.
Kontsevich, L. L., & Tyler, C. W. (2004). What makes Mona Lisa smile? *Vision Research, 44*(13), 1493-1498.
Labarre, W. (1947). THE CULTURAL BASIS OF EMOTIONS AND GESTURES. [Article]. *Journal of Personality, 16*(1), 49.
Landis, C. (1924). Studies of Emotional Reactions. II. General Behavior and Facial Expression. *Journal of Comparative Psychology, 4*(5), 447-510.
Langner, O., Dotsch, R., Bijlstra, G., Wigboldus, D. H. J., Hawk, S. T., & van Knippenberg, A. (2010). Presentation and validation of the Radboud Faces Database. *Cognition & Emotion., in press*.
Levin, D. T. (1996). Classifying faces by race: The structure of face categories. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 22*(6), 1364-1382.
Lundqvist, D., Flykt, A., & Öhman, A. (1998). The karolinska directed emotional faces. Stockholm, Sweden: Karolinska Institute
MacQueen, J. (1967). *Some methods for classification and analysis of multivariate observations.* Paper presented at the Proceedings of 5th Berkeley Symposium on Mathematical Statistics and Probability Berkeley
Maffei, L., & Fiorentini, A. (1973). The visual cortex as a spatial frequency analyser. [doi: DOI: 10.1016/0042-6989(73)90201-0]. *Vision Research, 13*(7), 1255-1267.
Marsh, A. A., Elfenbein, H. A., & Ambady, N. (2003). Nonverbal "accents": cultural differences in facial expressions of emotion. *Psychological Science, 14*(4), 373-376.
Masuda, T., & Nisbett, R. E. (2006). Culture and change blindness *Cognitive Science, 30*(2), 381-399.
Matsumoto, D. (1989). Cultural Influences on the Perception of Emotion. *Journal of Cross-Cultural Psychology, 20*(1), 92-105.
Matsumoto, D. (1992). American-Japanese Cultural Differences in the Recognition of Universal Facial Expressions. *Journal of Cross-Cultural Psychology, 23*(1), 72-84.
Matsumoto, D. (2002). Methodological requirements to test a possible in-group advantage in judging emotions across cultures: Comment on Elfenbein and Ambady (2002) and evidence. [Journal; Peer Reviewed Journal]. *Psychological Bulletin, 128*(2), 236-242.
Matsumoto, D., & Ekman, P. (1988). Japanese and Caucasian Facial Expressions of Emotion (JACFEE) and Neutral Faces (JACNeuF). [Slides]: Dr. Paul Ekman, Department of Psychiatry, University of California, San Francisco, 401 Parnassus, San Francisco, CA 94143-0984.
Matsumoto, D., & Ekman, P. (1989). American-Japanese cultural differences in intensity ratings of facial expressions of emotion. *Motivation and Emotion, 13*(2), 143-157.
Matsumoto, D., Haan, N., Yabrove, G., Theodorou, P., & Carney, C. C. (1986). Preschoolers' moral actions and emotions in Prisoner's Dilemma. *Developmental Psychology, 22*(5), 663-670.
Matsumoto, D., & Willingham, B. (2006). The Thrill of Victory and the Agony of Defeat: Spontaneous Expressions of Medal Winners of the 2004 Athens Olympic Games. [Journal; Peer Reviewed Journal]. *Journal of Personality and Social Psychology, 91*(3), 568-581.

Matsumoto, D., & Willingham, B. (2009). Spontaneous facial expressions of emotion of congenitally and noncongenitally blind individuals. [doi:10.1037/a0014037]. *Journal of Personality and Social Psychology, 96*(1), 1-10.

Mead, M. (1975). Review of "Darwin and facial expression." *Journal of Communication, 25*, 209-213.

Mesquita, B., & Frijda, N. H. (1992). Cultural variations in emotions: a review. *Psychological Bulletin, 112*(2), 179-204.

Miles, W. R. (1930). Ocular dominance in human adults. *Journal of General Psychology, 3*, 412-430.

Moriguchi, Y., Ohnishi, T., Kawachi, T., Mori, T., Hirakata, M., Yamada, M., et al. (2005). Specific brain activation in Japanese and Caucasian people to fearful faces. *Neuroreport, 16*(2), 133-136.

Morris, D. (1979). *Gestures, their origins and distribution*. New York: Stein and Day.

Morris, J. S., Friston, K. J., Buchel, C., Frith, C. D., Young, A. W., Calder, A. J., et al. (1998). A neuromodulatory role for the human amygdala in processing emotional facial expressions. *Brain, 121*(Pt 1), 47-57.

Munn, N. L. (1940). The effect of knowledge of the situation upon judgment of emotion from facial expressions. *The Journal of Abnormal and Social Psychology, 35*(3), 324-338.

Niedenthal, P., Krauth-Gruber, S., & Ric, F. (2006). *Psychology of emotion: interpersonal, experiential, and cognitive approaches*: Psychology Press.

Nisbett, R. E., & Masuda, T. (2003). Culture and point of view. *Proceedings of the National Academy of Science USA, 100*(19), 11163-11170.

Norenzayan, A., Smith, E. E., Kim, B. J., & Nisbett, R. E. (2002). Cultural preferences for formal versus intuitive reasoning. [doi:10.1016/S0364-0213(02)00082-4]. *Cognitive Science, 26*, 653-684.

Phelps, E. A., Ling, S., & Carrasco, M. (2006). Emotion Facilitates Perception and Potentiates the Perceptual Benefits of Attention. *Psychological Science, 17*(4), 292-299.

Pollack, A. (1996, 1996, August, 12). Happy in the East or smiling in the West :-). *The New York Times,* p. d5.

Roberson, D., Davidoff, J., Davies, I. R. L., & Shapiro, L. R. (2005). Color categories: Evidence for the cultural relativity hypothesis. [doi: DOI: 10.1016/j.cogpsych.2004.10.001]. *Cognitive Psychology, 50*(4), 378-411.

Roberson, D., Davies, I., & Davidoff, J. (2000). Color Categories Are Not Universal: Replications and New Evidence From a Stone-Age Culture. [doi:]. *Journal of Experimental Psychology: General, 129*(3), 369-398.

Rosenberg, E. L., & Ekman, P. (1994). Coherence between expressive and experiential systems in emotion. *Cognition & Emotion, 8*(3), 201 - 229.

Rosenberg, E. L., Ekman, P., & Blumenthal, J. A. (1998). Facial expression and the affective component of cynical hostility in male coronary heart disease patients. *Health Psychology, 17*(4), 376-380.

Rosenberg, E. L., Ekman, P., Jiang, W., Babyak, M., Coleman, R. E., Hanson, M., et al. (2001). Linkages between facial expressions of anger and transient myocardial ischemia in men with coronary artery disease. *Emotion, 1*(2), 107-115.

Rozin, P., & Fallon, A. E. (1987). A perspective on disgust. *Psychological Review, 94*(1), 23-41.

Rozin, P., Lowery, L., & Ebert, R. (1994). Varieties of disgust faces and the structure of disgust. *Journal of Personality and Social Psychology, 66*(5), 870-881.

Russell, J. A. (1994). Is there universal recognition of emotion from facial expression? A review of the cross-cultural studies. *Psychological Bulletin, 115*(1), 102-141.

Schyns, P. G., Petro, L. S., & Smith, M. L. (2007). Dynamics of Visual Information Integration in the Brain for Categorizing Facial Expressions. [doi: DOI: 10.1016/j.cub.2007.08.048]. *Current Biology, 17*(18), 1580-1585.

Schyns, P. G., Petro, L. S., & Smith, M. L. (2009). Transmission of Facial Expressions of Emotion Co-Evolved with Their Efficient Decoding in the Brain: Behavioral and Brain Evidence. *PLoS ONE, 4*(5), e5625.

Schyns, P. G., & Rodet, L. (1997). Categorization creates functional features. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*(3), 681-696.

Shweder, R. A. (1991). *Thinking through cultures*. Cambridge, MA: Harvard University Press.

Simoncelli, E. P., & Freeman, W. T. (1995). *The steerable pyramid: a flexible architecture for multi-scale derivative computation*. Paper presented at the Proceedings of the 1995 International Conference on Image Processing (Vol. 3).

Smith, F. W., & Schyns, P. G. (2009). Smile Through Your Fear and Sadness. *Psychological Science, 20*(10), 1202-1208.

Smith, M. L., Cottrell, G. W., Gosselin, F., & Schyns, P. G. (2005). Transmitting and decoding facial expressions. *Psychological Science, 16*(3), 184-189.

Sowden, P. T., & Schyns, P. G. (2006). Channel surfing in the visual brain. [doi: DOI: 10.1016/j.tics.2006.10.007]. *Trends in Cognitive Sciences, 10*(12), 538-545.

Susskind, J. M., Lee, D. H., Cusi, A., Feiman, R., Grabski, W., & Anderson, A. K. (2008). Expressing fear enhances sensory acquisition. *Nature Neuroscience, 11*(7), 843-850.

Tiddeman, B., Burt, M., & Perrett, D. (2001). Prototyping and transforming facial textures for perception research. *Computer Graphics and Applications, IEEE, 21*(5), 42-50.

Tomkins, S. S. (1962). *Affect, Imagery, Consciousness* (Vol. 1). New York: Springer.

Tomkins, S. S. (1963). *Affect, Imagery, Consciousness* (Vol. 2). New York: Springer.

Tomkins, S. S., & McCarter, R. (1964). What and Where are the Primary Affects? Some Evidence for a Theory. *Perceptual and Motor Skills, 18*, 119-158.

Turnbull, J. (1813). *A Voyage Round the World in the years 1800, 1801, 1802, 1803, and 1804 in which the Author visited the principle Islands in the Pacific ocean and the English settlements of port Jackson and Norfolk island* (Vol. 2). London.

Valentine, T., & Endo, M. (1992). Towards an exemplar model of face processing: The effects of race and distinctiveness. *Quarterly Journal of Experimental Psychology Human Experimental Psychology, 44a*(4), 671-703.

Vick, S.-J., Waller, B., Parr, L., Smith Pasqualini, M., & Bard, K. (2007). A Cross-species Comparison of Facial Morphology and Movement in Humans and Chimpanzees Using the Facial Action Coding System (FACS). *Journal of Nonverbal Behavior, 31*(1), 1-20.

von Humboldt, W. (1836/1999). *On language: On the diversity of human language construction and its influence on the menal development of the human species.* : CambridgeUniversity Press.

Vuilleumier, P., Richardson, M. P., Armony, J. L., Driver, J., & Dolan, R. J. (2004). Distant influences of amygdala lesion on visual cortical activation during emotional face processing. *Nature Neuroscience, 7*(11), 1271-1278.

Yuki, M., Maddux, W. W., & Masuda, T. (2007). Are the windows to the soul the same in the East and West? Cultural differences in using the eyes and mouth as cues to recognize emotions in Japan and the United States. *Journal of Experimental Social Psychology, 43*(2), 303-311.

Zhao, W., Serpedin, E., & Dougherty, E. R. (2006). Inferring gene regulatory networks from time series data using the minimum description length principle. *Bioinformatics, 22*(17), 2129-2135.