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Human ethology

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3.1. About brows: emotional and conversational signals[1]

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Introduction

We will distinguish two types of facial social signals – emotional expressions and conversational actions. Many of the same facial movements are recruited into each type of signal, although certain facial movements which appear in emotional expressions are rarely seen in conversational actions. To discuss these facial signals (and to study them), it is necessary to have an accurate way of characterizing the great number of movements which can flash across the face.

We will begin by explaining the advantages of an anatomically based system for describing facial action. How such a system works will be illustrated by considering the actions of the eyebrows. These movements have been chosen because the musculature is simpler and the number of distinguishable actions smaller than for other regions of the face. Another advantage of focusing just upon the eyebrows is that we need not worry about whether these actions are required by the process of speech articulation when later we consider the role of facial actions in conversation. The choice of eyebrow movements is also appropriate to a discussion of the origin of facial signals and the adaptive function of facial actions, since eyebrow movements have been the subject of somewhat divergent com-

[1] The research I report and much of the speculations are the product of collaborative work over the last twelve years with Wallace V. Friesen. This research has been supported by a grant MH 11976, and a Research Scientist Award MH 06092, from the National Institute of Mental Health, and a grant from the Harry Frank Guggenheim Foundation. I am indebted to Wally Friesen and Harriet Oster for their many criticisms and suggestions about this paper, and also to Linda Camras, Joe Hager, Maureen O'Sullivan and Rainer Krause for their comments.

mentary by ethologists (Blurton Jones and Konner 1971, Eibl-Eibesfeldt 1970, 1972).

There are but seven visibly distinctive eyebrow actions. This may seem a small repertoire, but it is larger than was recognized by previous students of facial movement. Each of these actions is the result of different muscles or combinations of muscles. The seven brow actions represent the repertoire allowed by the equipment. Each of these seven actions can be considered a candidate for recruitment into a social signal. Not all are. Five of the eyebrow actions are involved in emotional expressions. Two of the eyebrow actions play a major role in a variety of conversational signals.

We will describe what is known about the eyebrow actions in emotional expression. We will consider the controversy over universality, and attempt to reconcile contradictory claims. This will include a discussion of the problematic dichotomies of voluntary versus involuntary, deliberate versus automatic actions.

A number of conversational eyebrow signals will be described. We will ask why certain actions more than others are recruited into these conversational signals. Visual contrasts among the various eyebrow movements, and differences in ease of performance, are relevant but do not provide the answer. We will also explain our rationale for distinguishing conversational from emotional signals.

Finally, we will address the question of why certain actions are selected for certain signals. For example, why are the eyebrows typically not raised in anger and lowered in surprise; and why have there not been reports of lowered brows in greetings, but only of raised brows? We will consider the evolutionary view that these movements originally had some biologically adaptive value to our progenitors and were selected and modified for their role as signals. Our discussion will reveal problems in applying this explanation to the role of eyebrow actions in emotional expressions. While we will not resolve the issue of the origin of these facial actions, our discussion will draw attention to the type of evidence that is needed to discover the relative contribution of biological and cultural processes to the development of facial signals.

Before proceeding, we should note that in limiting the focus of this paper to the eyebrows we do not imply that these actions should be studied in isolation from the rest of facial action. It would be equally misguided to study facial action in isolation from head movement, other facial sign systems,[2] body movement, vocalizations and speech, and all

[2] Elsewhere (Ekman 1977a) we have distinguished among static, slow and rapid facial signs, describing the different information provided by each. Rapid signs include changes in

the usually unspecified phenomena which slip so easily under the rubric 'social context'. The focus upon eyebrow movements is a heuristic for exposition, not a recommendation for research.

Describing facial action

> With few exceptions, present-day students of animal communication seem unaware of the criteria that they, themselves, have used in establishing catalogues of behavior units. Each catalogue is presented as a *fait accompli*, with little or no justification for the particular choice of behavioral units or elements. Yet, what stage in our research could be more crucial than this initial choosing of behavioral units! Upon it rest all of our subsequent records of communication interactions and any conclusions that we may draw from them, as well as any attempt by others to replicate our results. (Altmann 1968: 501)

These comments apply with equal force to students of human communication, and in particular to those who have proposed ways to measure facial action. The descriptive systems have been incomplete, without an explanation of what has been left out or why. The units or categories have sometimes specified a single action, sometimes included complex actions due to a number of muscles, often without acknowledgment of this difference. Descriptions have often been contaminated with inference about meaning, so that it is not possible to use the descriptions to test whether the meanings are indeed so associated.[3] The specification of units has sometimes been so vague that investigators cannot know if they are cataloguing the same actions. Descriptions of actions have occasionally been anatomically incorrect.[4] And, these systems have not dealt with the ways in which individual or age-related differences in physiognomy may confuse the recognition of certain actions. (See Ekman and Friesen 1976 for a review of facial measurement systems.)

These problems can be avoided or diminished by an approach based on the anatomy of facial action. Inspection of facial movement can be in-

vascular supply, temperature, coloration and non-visible muscle tonus, as well as the muscular actions which are discussed here.

[3] Examples of contaminating inference with description are 'aggressive frown' (Grant 1969); 'lower lip pout' (Blurton Jones 1971); 'smile tight-loose o' (Birdwhistell 1970); 'low frown' (McGrew 1972); 'sad frown' (Brannigan and Humphries 1972).

[4] While noting that the inner corners of the brows move up in the sad frown, in describing this category, Brannigan and Humphries (1972) wrote that the brows are 'drawn down at their outer end'. This cannot happen. The oblique slope of the brows is produced either by the action of the inner portion of the *frontalis* muscle, or by that action together with the *corrugator* muscle. Once such anatomically incorrect descriptions are made available, they can spread. For example, Lewis, Brooks and Haviland (1978) adapted Brannigan and Humphries' scoring categories in their research on infant facial behavior, incorporating this fallacious account of the 'sad frown'.

formed by knowledge of the mechanics of facial action.[5] How the equipment works – how single muscles and combinations of muscles change appearance – provides only part of the basis for a descriptive system. It is necessary also to take into account which variations in performance observers can distinguish. Otherwise the descriptive system would be unreliable.

When we turned to the literature on the neuroanatomy of facial movement, we expected to find muscles distinguished one from another on the basis of:

differences in how they change appearance;
capability for independent action;
feedback circuits (through proprioception or cutaneous means) which allow a person to become aware of what has moved on his face.

These issues have been considered but not studied systematically for the entire face. Anatomists have named muscles in the face largely on the basis of the appearance of different strands or bundles of muscle fibers when the skin was removed (S. Washburn, personal communication, 1975). Duchenne (1862), Hjorstjö (1970), and Lightoller (1925) are exceptions who were interested in how muscles change appearance.

Building upon their findings, and incorporating the descriptions scattered in many anatomy texts, Friesen and I took the following steps to determine the independent units of facial action. Over the course of two years, we learned how to move our own facial muscles by studying anatomy texts, palpating our muscles, and comparing what we would see in a mirror with the descriptions of others. We observed the changes in the surface of our own faces when a needle placed into a muscle delivered electrical current. And, with a needle in place, we voluntarily moved a muscle to see if there was a change in the electrical activity. (The work with the needle insertions was painful and we pursued it only with the few muscles about which we were in doubt.) We studied the facial actions of fourteen other people who learned how to control specific muscles following our instructions. Also, we studied the spontaneous facial actions found in the records of hundreds of persons from a number of cultures, to seek movements not previously identified.[6] This work provided the basis for specifying what the equipment can do.

[5] Blurton Jones (1971) was much more concerned and knowledgeable about the anatomy of facial action than other human ethologists, although he decided not to base his descriptive system on anatomical units or criteria.

[6] We did not uncover any evidence of new muscular actions when studying the records of non-western people, although we did note certain combinations of actions which are not commonly seen in western cultures. Our work on the anatomy of facial action was guided

We also considered what the perceiver can reliably distinguish. We carefully studied through repeated viewing and slow motion more than 5000 different combinations of specific muscular actions. We taught eight people how to recognize facial actions, and then determined what they could reliably distinguish. Based on these findings, we then wrote a manual (Ekman and Friesen 1978) on how to score facial behavior. Using this manual six other people learned to distinguish facial actions in the terms we proposed, achieving high reliability.

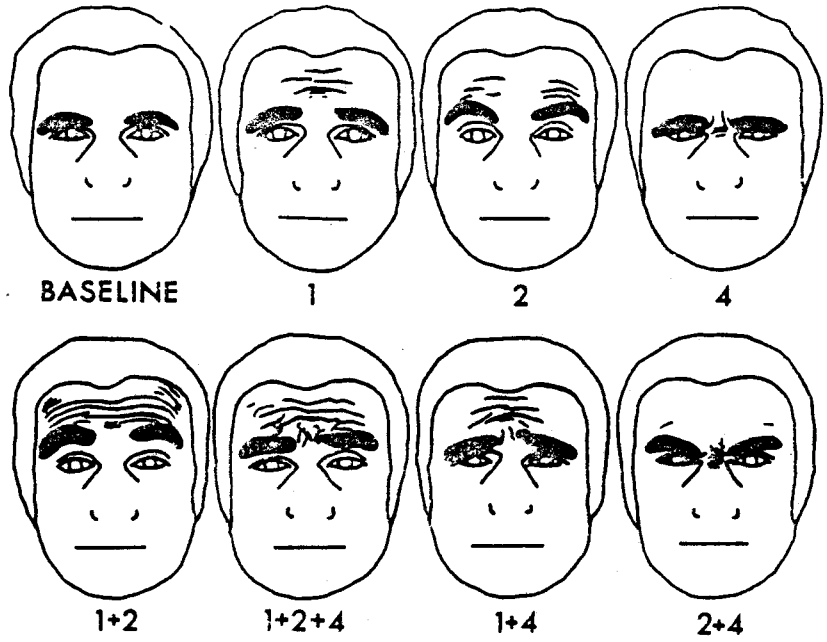
The descriptive units are called Action Units rather than muscle units. They are the product of what the muscular equipment can do and what the perceiver can distinguish under optimal viewing circumstances. For most of the units there is a one-to-one correspondence with what most, but not all, anatomists distinguish in the naming of muscles. Occasionally more than one Action Unit is provided for what anatomists describe as a single muscle. This is because we have found that visibly different actions are produced by different parts of that muscle. In one instance, described below, we have combined into a single Action Unit what anatomists distinguish as three separate muscles.

Consider now what this blending of anatomy (for the person who makes the facial action) and perceptual capability (for the observer of the action) provides for one part of facial action, the movement of the eyebrows. There are three elemental Action Units, which can occur singly or can combine to produce four other movements. Figure 1 shows a tracing from photographs of these Action Units and a baseline example of no action. Action Unit 1 designates the appearance changes when just the medial portion of the *frontalis* muscle contracts. The inner corner of the eyebrow is raised, and the skin in the middle of the forehead is pulled up, which may cause short wrinkles to appear or deepen in the center of the forehead.

Action Unit 2 designates the appearance changes when just the lateral portions of the *frontalis* muscle contract. The outer corners of the eyebrows are raised, and the skin in the lateral portions of the forehead is pulled up, which may cause short wrinkles to appear or deepen in the lateral portions of the forehead.

Action Unit 4 designates the appearance changes when the *corrugator*, *depressor glabella* and/or *depressor supercilli* contract. The eyebrows are

by German, French, Swedish, English and American anatomists. We also studied Burkitt and Lightoller's (1926–7) and Huber's (1931) accounts of the differences in facial anatomy in other racial groups. Their work suggests some anatomical variations, but not ones which would produce unique movements.



1. Action Units for the brow/forehead.

pulled down and drawn together, the skin between the brows is bunched, often wrinkling or deepening a wrinkle between the brows. These three muscles are combined into one Action Unit because we have rarely observed their separate occurrence, and observers cannot reliably distinguish one from another.[7]

Let us consider three other muscles which can have an influence on the eyebrows. The *occipitalis* muscle reaches down from the scalp. It pulls the forehead skin upwards, pulls the scalp backwards and sometimes produces a very slight lift to the eyebrows. We will not further consider this

[7] Oster (1978) believes it is possible to distinguish *corrugator* from *depressor glabella* in young infants, and that they are differentially related to subsequent smiling and crying. In one child with a cranio-facial malformation, we found that the action of the *depressor glabella* was quite evident, probably because the child did not appear to have a functioning *corrugator* muscle. In children and adults we believe it is not useful to distinguish *corrugator* from *depressor glabella*, because they often co-occur and when they do not are difficult to distinguish. If further empirical work suggests they can be reliably distinguished, this would easily be done within our measurement system. Action Unit number 3 has been left vacant in our system so it could be later used if it proves necessary to separate *corrugator* and *depressor glabella*.

action since its influence on the eyebrows is minor and often not visible. No one has observed this muscular action as a social signal, although Birdwhistell (1970) claimed that the basal position of this muscle varies among social groups.[8] The *levator labii superioris alaeque nasi* can lower the brows, particularly the inner corners, in addition to wrinkling the nose, pulling the nostril wings upwards, and lifting the upper lip. This action is scored in our measurement system, but need not concern us here, since it involves a change across the entire face, not just an eyebrow movement. Finally, the outer portion of the *orbicularis oculi* muscle (*pars orbitalis*) can slightly lower the eyebrows as part of an action which draws skin surrounding the eye orbit inwards, producing crow's-feet wrinkles, and narrowing the eye fissure. This action is also scored in our measurement system, but will not be of concern here since it produces changes in the eye region as well as in the brows. It should be noted that in focusing just upon actions which change the appearance of one region of the face – eyebrows and forehead – we must be cognizant of the influence of these other facial actions. Otherwise we might draw spurious conclusions about the relationship between eyebrow movement and changes in the eye region, nose or lips.

Return now to consider the three single Action Units which change the appearance of just the eyebrows and forehead. Each of them can occur unilaterally or bilaterally. The extent of action may vary for each. Often bilateral actions are asymmetrical, stronger on one side of the face than the other. These three Action Units are the building blocks for the four combinations shown in figure 1. Together the three single actions and the four combinations provide a complete picture of the repertoire of distinguishable movement in this region of the face.

The other well known systems for describing facial action provide only partial coverage of these seven possibilities. Birdwhistell (1970) included only two; Blurton Jones (1971) and McGrew (1972) each distinguished three; Grant (1969) and also Brannigan and Humphries (1972) each distinguished four of the seven possibilities. None allowed for Action Unit 2, an infrequent action. When it occurred, it was probably unwittingly categorized with 1+2. Only Brannigan and Humphries allowed for Action Unit 1; the others probably included it with 1+4 which they did include. None allowed for 2+4, an infrequent action. Only Grant men-

[8] While this may be so it is documented only by Birdwhistell's impressive performances using his own face. The issue of social or psychological differences in the baseline muscle tonus of the face is a rich area for research, which is just now beginning (cf. Schwartz *et al.*, 1976).

tioned 1+2+4, although it was not one of his scoring categories. This is a frequent action, and it is not clear what these investigators did when they saw it.

Omission of some behaviors from a system for describing facial action is not necessarily problematic, although a complete system is preferable. The problem arises if the omissions were unwitting, and even worse if what was omitted is unwittingly combined with other different actions. Combining into one functional category a 1+2 and a 2, or a 1 with a 1+4, should rest upon evidence on how these are used, which can never be obtained if the distinctions are collapsed in the initial description.[9]

The seven eyebrow actions shown in figure 1 are candidates for a role in social signals. First, we will consider which actions are recruited in emotional expressions, then which function as conversational signals.

Emotional expressions[10]

There is now a large body of evidence that specific patterns of facial actions universally signify particular emotions. Quantitative studies have provided evidence in more than thirteen literate cultures and two visually isolated preliterate cultures. Qualitative studies support this evidence in a great number of visually isolated cultures. These studies include the work of anthropologists, ethologists, pediatricians, psychologists and sociologists. The people studied have included neonates, children and adults; mostly sighted but some blind persons. Naturalistic observations and laboratory experiments have been conducted. Spontaneous and contrived facial expressions have been measured in various contexts, and the interpretations of faces by members of different cultures have been compared (see Ekman 1973 for a review of this work).

Despite such evidence some still argue that there are no universals in facial expressions of emotion. 'Since natural languages do not in general

[9] Throughout the rest of this report we will refer to these seven eyebrow actions in terms of their Action Unit numbers. This will require the reader to consult figure 1 to recall the designated movements. Admittedly, the figure gives only a partial representation of the movements, as it is only a tracing of a still picture. In our *Facial action coding system* manual each Action Unit and combination is depicted in cinema and described in considerable detail. The alternatives for describing facial action are cumbersome and vague. The Latin names are long and provide little idea about the movement's appearance. Terms such as oblique slope, entire brow raise, inner corner brow raise, are just as cumbersome, and may mislead by over-simplifying the range of changes in appearance which occur for each Action Unit.

[10] Although differing in detail, the account of the interrelationship between facial expression and other responses described here was first most explicitly and systematically presented by Tomkins (1962–3). He offered a different, but not contradictory, view of the characteristics common to the elicitors of each emotion.

associate particular sounds or combinations of sounds with particular meanings, the linguistic analogy does not suggest there will be any consistent relationship between nonverbal signal and response when such signals are observed in differing cultural environments' (Leach 1972: 329). That same view has been most vigorously argued by Birdwhistell (1970) and most recently by Mead (1975). Elsewhere (Ekman 1977b), we have explained how a linguistic analogy is misleading about facial expressions of emotion, although useful in describing the function of facial conversational signals. We have attempted to explain the basis for the disagreement between those who argue from a linguistic analogy and those who argue an evolutionary view, offering a theoretical framework which attempts to embrace both, to reconcile the disagreement. Here, we will only summarize some of the main issues.

One major source of disagreement has been the failure of many of the universalists to explain what they mean by emotion terms such as anger, fear, surprise, sadness, disgust, happiness, etc. We (Ekman 1977b) have suggested that these terms imply a complex package of information. Consider only three components of this package: elicitors, co-occurring responses, and subsequent interpersonal behavior. Elicitors refer to the stimulus events, external or internal, which precede and appear to regularly call forth an emotional expression. The co-occurring responses refer to skeletal muscular actions, vocalizations, autonomic nervous system changes, memories, images, expectations and other cognitions which occur simultaneously with the emotional expression. Subsequent interpersonal responses refer to a more complex pattern of activity which describes how a person copes with the source of emotional arousal. There is both universality and cultural variation in regard to each of these components of emotion. We will use just a few examples.

Consider the elicitors of surprise. Universally, surprise elicitors are novel, unexpected and sudden. This characterization requires that the specific stimuli for surprise must vary since what is expected will vary with particular social contexts. Therefore, surprise elicitors cannot be uniform for any one person, social group or culture. Whether an investigator finds evidence of universality or cultural variation in elicitors of emotional expression will depend, in part, upon the level of abstraction employed in his analysis.

The co-occurring responses for surprise which are likely to be universal[11] include muscular movements which orient the person towards the

[11] Not all of the co-occurring responses should show universality; e.g. memories, images, expectations should be quite variable.

surprising event, a quick inhalation, and if a sound is made, one that is abrupt in onset and offset like 'wow', 'oh', 'whew'. By contrast, in disgust the muscular responses orient the person away from the source, an exhalation is likely, and the sound is likely to resemble a regurgitation noise, so that 'yucch' would be more probable than 'mmhmm'. These immediate responses are probable, common, but not likely to be fixed. While there is no evidence directly pertaining to this matter, casual observation suggests that people can interfere with these immediate responses. In line with Hamburg's (1963) view of the evolution of emotion, it seems reasonable to propose that social learning could be organized to inhibit or replace these responses, but such learning might be a bit harder than experiences which support, amplify or extend these responses.

The same potential for variability exists when it comes to the subsequent coping responses, although here individual and group differences loom larger. We cannot use the example of surprise, since we know of no common coping response subsequent to surprise; it depends upon how the surprising event was evaluated. One might say that fighting, verbally or physically, is a coping response in anger, and flight, physically or through social withdrawal, is a coping pattern in fear. Yet it is only by ignoring enormous variations that one could argue for universality here. How an individual copes with anger depends upon his own past experiences and how he evaluates the particular occasion. Subsequent coping responses are not subject to random variations. There are some commonalities across divergent social groups due to biologically based predispositions and constraints, but clearly social learning, which can be quite variable, plays a major role.

Thus when we begin to specify just what is meant by emotion, what it may be that a facial expression signifies, it is clear that it is neither universal nor totally variable. There are commonalities and variability in different respects and to a different extent depending upon which aspect of emotion is considered.

Another major source of confusion and contradiction about emotional expressions has to do with the issue of whether facial expression is voluntary or involuntary. The accounts of the cultural relativists have suggested or implied that facial expressions are deliberate, feigned, chosen, employed as masks, unreliable indicators of feelings, the product of social conventions about which feelings should be shown in what context. Some of those arguing for the universalist position have implied that facial expressions are involuntary, occur without awareness or

choice, are difficult to control, and may reveal information the person is trying to inhibit. Both views are partially right; neither offers a satisfactory account.

Neurological studies of deficits in facial activity associated with different brain lesions have suggested that facial expression has dual control (Myers 1969). While the neural mechanisms which govern facial activity are still far from understood, it seems clear that we cannot consider facial action as the exclusive product of the 'old' or 'new' brain, of hypothalamic or cortical activity. The distinction between voluntary and involuntary has merit, but it is too simple.

One problem with this distinction is that it does not deal with many voluntary actions which become well established habits and automatic in their occurrence. Many of the facial conversational signals that we will describe later are just such instances. Using the eyebrows to mark emphasis during speech can be done voluntarily, but usually it is done with little awareness or seeming choice. A person who customarily uses a particular eyebrow emphasis marker can, if he focuses his attention upon it, interfere with such a habit, but it will reappear when he stops thinking about it. Later when we discuss the differences between emotional and conversational facial signals we will speculate about the neural basis of these two types of signals.

Even when considering just the emotional expressions, the distinction between voluntary and involuntary misses some of the complexities. Consider a few pieces of evidence which come from our studies of the facial actions observed when people attempt to conceal how they feel (Ekman and Friesen 1969a, 1974). Some people are quite capable of inhibiting facial expressions of emotion when they feel disgusted, pained, afraid, or distressed. Many others cannot manage to do so and report a struggle to control facial action. Many people can put on facial expressions which mask how they feel and do this so well that they successfully mislead others. While there are suggestions that these false expressions differ from felt ones, the differences are subtle and typically go unnoticed.

There are not only such individual differences but also systematic group differences in facial expressions of emotion. We (Ekman and Friesen 1969b, 1975) proposed the term 'display rules' to describe social norms which specify who can show what emotion to whom, when. Some of these rules are learned so well that they operate automatically, without choice or even awareness. Others are known but not acquired as habits; they are ideals to be followed, but not well practiced. These display rules

cover many signs of emotion, not just the face, although facial expression receives attention as a very visible, easily decipherable cue. We (Ekman 1972, Friesen 1972) found evidence to support our expectation that cultural differences in facial expressions sometimes may be due to different display rules overlying and disguising universals. When alone, Japanese and Americans showed virtually the same facial actions while viewing a stressful film. The very same measurements of facial action revealed marked differences between members of these two cultures when the stressful film was viewed in the presence of an authority figure. The Japanese, more than the Americans, controlled facial expressions of disgust, pain, distress and fear and masked those actions with smiling.

The observations by cultural relativists of variations in facial actions associated with emotion may be the consequence of their observing social occasions where different display rules were operative. The universalists may have focused upon those occasions where display rules to disguise were not operative, or where the same display rule was followed in the cultures compared. The universal facial expression of anger (or any other emotion) will not invariably signify that the person observed is angry. It may just as well mean that he wants to be viewed as angry. And the failure to observe a facial expression of anger does not necessarily mean that the person is not angry. The system is not that simple.

Elsewhere (Ekman 1973, 1977b) we have discussed these and other issues which had led to confusion about universality and cultural differences in facial expression, and we attempted a more explicit description of how cultural and biological influences contribute to facial expression. Now, having indicated some of what we mean by emotion and the constraints on what is meant by saying expressions are in any way universal, let us consider the seven eyebrow movements. We will consider their role in only a few emotions, just those emotions about which there is evidence that the facial actions have some universal association with either an emotion term, an elicitor, or co-occurring responses.

In sadness, either Action Unit 1 or the combination 1+4 occurs, together with the relaxation of the upper eyelid (probably *levator palpebralis superioris*), sometimes a pulling in of the skin around the eye and slight raising of the cheeks (*orbicularis oculi, pars orbitalis* and *zygomatic minor*), a slight depression of the angle of the mouth (*triangularis*), sometimes also a pushing up of the chin (*mentalis*) and lowering of the lower lip (*depressor labii inferioris*). In the distress cry some of the facial actions change. Action Unit 4 is most important in the eyebrows, with less evidence of Action Unit 1. This is joined by the inner and outer portions of

orbicularis oculi, raising the cheeks, pulling in skin towards the eyes, and tightening the eyelids. Around the mouth the actions described for sadness are joined by horizontal stretching of the lips (*risorius* and/or *platysma*), lowering of the mandible, lowering of the lower lip (*depressor labii inferioris*) and raising of the upper lip (*levator labii superioris*).

In surprise, the combination 1+2 is accompanied by raising the upper eyelid (*levator palpebralis superioris*) and dropping the jaw (relaxation of the *masseter*).

In fear, the combination 1+2+4 is accompanied by raising the upper eyelid and tightening the lower eyelids (*orbicularis oculi, pars palpebralis*), and by horizontal stretching of the lips (*risorius* and/or *platysma*).

In anger, Action Unit 4 without any brow raising is accompanied by the same actions around the eyes as described for fear, with the lips either pressed firmly together (*orbicularis oris* and perhaps *mentalis*), or squared and tightened (some combination of *orbicularis oris*, *levator labii superioris quadratus*, and *depressor labii inferioris*).

For two emotions – disgust and happinesss – no specific eyebrow actions are recruited. (It may appear that the brows are lowered in disgust, but this is due to the involvement of either *orbicularis oculi* or *levator labii superioris alaeque nasi* action recruiting *depressor glabella*.) There may be other facial expressions of emotion, but those we have described – fear, surprise, anger, sadness, disgust and happiness – are the only ones for which there is evidence of some kind of universality.

Table 1 recasts this description of the involvement of eyebrow actions in the emotional expressions, to highlight the role of each Action Unit and combination. We have not found a simple way to describe or explain which actions are involved in emotional expressions and which are not. Some single Action Units signify emotion (when combined with lower face actions), some combinations also do so, but not every possible single action, nor every possible combination. At the end of this paper we will show how consideration of the adaptive consequence of some of these eyebrow actions may account for their involvement in particular emotions; but that line of reasoning does not explain the role of all the eyebrow actions in emotional expression.

Let us consider briefly whether any of the eyebrow actions signify emotion when they stand alone without any other muscular action visible in the face. It is common for some of these eyebrow actions to occur without any other facial movement. There has been very little study of such isolated eyebrow actions, although we have made a few studies within the United States and are just beginning a cross cultural study. We

Table 1. *Role of eyebrow actions in emotional expression*

	With eye region and lower face actions
Action Unit 1	
without other brow actions	SADNESS
with Action Unit 4 (1+4)	SADNESS
with Action Unit 2 (1+2)	SURPRISE
with Action Units 2+4 (1+2+4)	FEAR
Action Unit 2	
without other brow actions	
with Action Unit 1 (1+2)	SURPRISE
with Action Unit 4 (2+4)	
with Action Units 1+4 (1+2+4)	FEAR
Action Unit 4	
without other brow actions	ANGER OR DISTRESS
with Action Unit 1 (1+4)	SADNESS
with Action Unit 2 (2+4)	
with Action Units 1+2 (1+2+4)	FEAR

expect that when the eyebrow actions are not joined by other facial movements they may still convey information about emotion, but that the information is less precise, that it is about a family of related emotions not specific to a single emotion. And we expect to find much more variability across cultures in precisely what is signified when only the eyebrows are active. What follows are best viewed as hypotheses, supported only in one culture by a limited number of studies.

The combination 1+2 will be associated with positive rather than negative emotions, but could be a surprise or interest signal. It will also be confused with conversational signals which employ this action (questioning, doubting, greeting, emphasizing).

Action Unit 1, and the combinations 1+4 and 1+2+4 will be associated with either fear or sadness but not with anger or disgust, or with positive emotions.

Action Unit 4 will be associated with anger, disgust, perplexity and more generally with difficulty of any kind. It will also be confused with the variety of conversational signals which employ this action.

Two of the seven eyebrow actions appear to play no role in emotional expression: 2 and 2+4. Hjorstjö (1970) said 2+4 was a sign of rage, and Eibl-Eibesfeldt (1972) noted that this action is shown in Japanese theatrical masks depicting anger or rage. We have seen this eyebrow action in Etruscan, early Roman, and Renaissance art as well as in comic strips. Yet we know of no evidence showing that this action is often employed in

spontaneous or even posed facial expressions. Action Unit 2 is also rare in emotional expression, and there has been little commentary of any kind on this eyebrow movement.

Conversational signals

Compared to the emotional expressions, relatively little is known about conversational signals. We do not know of any quantitative studies of these actions. There have only been scattered observations, unsubstantiated by careful description, without systematic cross cultural comparisons. We began to observe these actions a few years ago, and started systematic study only in the last year. What we report must be considered preliminary, tentative, and only a suggestion about what may be found. First, we will consider facial actions shown while speaking, then the facial actions shown while listening, and finally actions which may occur when people converse without words. Again our focus will be upon eyebrow actions, which are probably among the most frequent facial actions employed as conversational signals.

Speaker conversational signals

Baton. Efron (1941) proposed this term for hand movements which appear to accent a particular word as it is spoken. We have noted that batons appear to coincide with primary voice stress, or more simply with a word that is spoken more loudly. When we have asked people to place the voice stress on one word and put the baton on another word, most cannot do so. Usually the voice emphasis shifts to the locus of the baton. The neural mechanisms responsible for emphasis apparently send impulses to both voice and skeletal (or facial) muscles simultaneously when both modalities are employed. We expect this relationship between baton and voice emphasis to be maintained across languages and cultures, but have no data as yet.

Birdwhistell (1970) and Eibl-Eibesfeldt (1972) have commented that facial actions can emphasize speech, but neither distinguished between a baton and what we next describe as an underliner. Birdwhistell did not specify any particular facial emphasis action; Eibl-Eibesfeldt mentioned only what we call 1+2. In both systematic and casual observations of Americans we find that 1+2 is the most frequent baton. Next most common is Action Unit 4. Much more rare is the combination 1+4, although some people frequently employ this action as a baton. (The

American actors Woody Allen and Zero Mostel are examples who do so.) Almost any other facial action could be employed as a baton, but few are. The upper eyelid raise is sometimes used, as is nose-wrinkling, although the latter is more typical of females than males.

Most people show both 1+2 and 4 batons, more of the former than the latter, but some of each. We are beginning a study to test our hypothesis that when Action Unit 4 is employed as the baton there is some evidence of uncertainty, perplexity, doubt or difficulty of some kind. This will not always be so, but sufficiently to reject the notion that the occurrence of 4 versus 1+2 is random.

Underliner. We have proposed (Ekman 1977b) this term to describe a movement which also provides emphasis, but in this case the emphasis stretches out over more than a single word. Underliners coincide with one of a variety of speech changes which provide emphasis – sustained loudness, increased pauses between each word spoken, stretching out the words as they are spoken.

Hand movements, postural leans, sustained gaze or facial action may function as underliners. As with the baton, Action Units 1+2 and 4 are the most common, and here too we expect to be able to show that the conversational context in which each is shown differs at least some of the time. As with batons, some people show a preponderence of 1+2 or of 4, and a few people primarily employ 1+4.

There are many occasions when people mark emphasis in their speech without either a baton or an underliner. We are not optimistic about being able to predict when a baton or underliner will be used and when emphasis will be carried just by voice, although perhaps there might be some weak relationship with overall involvement in what is said. There may well be differences between social groups in the frequency of batons or underliners, conceivably also in the type of action employed.

Punctuation. Both 1+2 and 4 appear to be employed as punctuation marks. When a person describes a series of events, either of these actions may sometimes be placed in a pause after each event in the series, much as a comma would be located if the speech was written.

Either 1+2 or 4 may be placed in a juncture pause at the end of a phonemic clause much as if it was a period or exclamation point. Our hunch is that there again is a difference in the semantic context if 1+2 or 4 is so located. With the 1+2 the context seems to be more of an exclamation over something amazing, incredible, etc. If the 4 is placed at a juncture

pause, the semantic implication appears to be one of seriousness, importance, doubt, perplexity, or difficulty.

The question mark, another punctuation action, has been subject to more commentary and some preliminary study, so we describe it separately.

Question mark. Birdwhistell (1970), Blurton Jones (1967), Darwin (1872), and Eibl-Eibesfeldt (1972) all commented on the use of brow raises (probably 1+2, not 2) to indicate a question. Linda Camras, a post-doctoral research fellow at our laboratory, has begun to examine eyebrow actions in the course of conversations between mothers and their five year old children. Her preliminary findings suggest that both 1+2 and 4 are used in question statements, although 1+2 is more common than 4. Her findings support our prediction that (just as with batons and underliners) there is a difference in the context in which 1+2 or 4 occur. If the mother is less certain about the answer to her question, more in doubt or perplexed, then 4 is more likely to occur than 1+2. When observers were allowed to listen to and watch the context which immediately preceded the use of either 1+2 or 4 in a question, they were able to do better than chance in guessing which eyebrow action occurred, although often they could not explain their guess.

Camras also has preliminary evidence which may suggest when a brow action is most likely to be recruited to signal a question mark. A 1+2 is more likely to occur in a question when the words do not provide a clue that a question is being asked. For example, if the statement does not begin with a 'what, where, who, when or which', a 1+2 is more likely than in a statement that has such a verbal or syntactic indication of questioning.

Word search. Goffman (chapter 3.2 below) interpreted the speaker's 'ah' or 'uh' as making 'it evident that although he does not have the word or phrase he wants, he is giving his attention to the matter . . . assuring that something worse than a temporary loss of words has not happened, and incidentally holding the speaker's claim to the floor'. We have noted (Ekman 1977b) that hand movements (e.g., finger-snapping or movements which seem to be trying to pluck the word from space) occur in just this conversational location and may also serve to help hold the floor. In a similar way Action Unit 4 may indicate also that word search is occurring, and incidentally hold the speaker's claim on the floor. This action often occurs during one of the 'ah' or 'uh' word search pauses. Another com-

mon action during word search is 1+2 with the eyes looking up as if the word was to be found on the ceiling. Apart from the brow action, during word searches it is typical for the gaze to be directed at an immobile spot, reducing visual input. This visual inattention may increase the risk of losing the floor, and the brow actions may serve to signal the listener not to interrupt or take over the speaker turn.

Other speaker conversational signals. We see many other eyebrow actions during speech which we do not yet know how to characterize. There may be actions which are employed as signals for turn-taking. And there may be facial actions which serve syntactic functions.[12] So far these remain elusive, but our search has just begun.

Listener's responses

Dittmann (1972) described how the listener provides head-nods, smiles and 'um-humms' during conversation. He found that these actions occur at specific locations in relation to the structure of the speaker's words. In classroom exercises we have found that students find it hard to withhold listener responses, doing so only as long as they concentrate on this task. When they succeed, the speaker usually inquires whether something is wrong, whether they are listening, etc.

What Dittmann described can be termed *agreement* responses, indicating not only that the listener is attending, but that he understands and does not disagree with what is being said. 1+2 with either a smile, a head-nod, or an agreement word is also an agreement listener response.

Eyebrow actions also function as calls for information. The listener may show Action Unit 4 when he does not understand what the speaker has said. Or the 4 may be more of a metaphorical comment that he finds what the speaker has said to be figuratively, not literally, incomprehensible. Another call for information is the question mark 1+2 shown by the listener much as it is performed by the speaker. As with Action Unit 4, 1+2 may indicate that the listener does not understand, or metaphorically it may signal his incredulity at what the speaker has said. If the latter is the signal, it will be more explicit when joined by other facial actions described below for the disbelief message.

[12] Liddell (1975), working in Bellugi's laboratory, used an early version of our facial measurement system to isolate a particular set of facial actions which mark the occurrence of a relative clause when deaf people use American Sign Language.

Some people make movements around the mouth which seem preparatory to speaking. Such movements conceivably might also signal to the speaker when the listener wants his turn to speak. We have not noticed eyebrow actions serving this function.

The listener could use eyebrow movements to emphasize the speaker's words. We have observed this rarely, only between people very intimately involved.

There are probably other eyebrow listener responses but we have not focused as much on these in our research.

Conversational signals without speech (emblems)

So far we have considered only facial actions which occur during spoken conversation. These actions are usually ambiguous outside of the context of talk in which they occur. Their role is known by examining what is being said, intonations, pauses, turns, etc. Now consider facial actions which can occur when there is no talk yet communication is intended. We have used Efron's (1941) term *emblem* to refer to such actions with specific semantic meaning; most of our previous work on emblems has focused on hand movements.

When the burden for communication is totally on other than the verbal, we have not found eyebrow actions to carry the message without the recruitment of other facial actions, head movements, gaze direction, or vocalizations. An isolated facial action could be an emblem (e.g. the wink is such an instance using an eye muscle), but we do not know of such single muscle eyebrow emblems.

All of the signals described below are also shown by speaker and listener during spoken conversation. What distinguishes them, however, is that these actions can be used with little ambiguity when the participants choose not to use any words at all.

Flash. Although Eibl-Eibesfeldt's account of this facial action emphasized a repeated brow raise (1+2), he also mentioned an upwards tilt of the head, a smile, and an upper eyelid raise as part of the greeting signal. Our own observations of the flash in New Guinea suggest the flash typically involves one or another of these actions in addition to 1+2. We disagree with Eibl-Eibesfeldt about the universality of this action as a greeting signal. It is widespread, but our own studies of symbolic gestures and those of our students (see Ekman 1976 for a review) suggest that it is not employed as a greeting in a number of cultures.

(Since discussion of the flash occurred at the conference, let me add some comments to amplify our view of this action. We do not believe that any specific conversational facial signal is innately programmed and therefore none is likely to be universal. We do believe there are reasons (explained later in this paper) why it would be more likely for 1+2 to be chosen as the brow movement for a greeting than 4 or 1+4 *if* a culture did have a brow movement for a greeting. Not believing that this brow action is built into the organism to signal greetings, we do not agree with Eibl-Eibesfeldt's reasoning in discussion that the failure to use it represents an instance of cultural suppression.

Why would our distinguished colleague believe he has seen this brow movement universally as a greeting when we do not? In part this may be because the movement of raising the brow is a frequent action occurring in many different conversational signals – emphasis, yes/no, question marks, exclamation marks, etc. In part it may be because the brow raise can be part of a surprise emotional expression. It would not be uncommon for people to be surprised or to show mock surprise when first seeing another person. Nor would it be uncommon that a person might show a question mark or an exclamation mark upon first seeing another unexpected person arrive. It would be necessary to rule out these uses of the brow raise, in order to be certain that all appearances of the brow raise during initial encounter are truly greetings.)

Disbelief. In Americans (and probably therefore in at least some European countries), when the combination 1+2 is joined by pulling the corners of the lips down (*triangularis*), relaxing the upper eyelid, pushing up the lower lip (*mentalis*), raising the upper lip, and /or rocking the head from side to side, the message is disbelief or incredulousness.

Mock astonishment. The performance for this signal involves the combination of 1+2 accompanied by raised upper eyelid, dropped open jaw, and an exaggerated element to the performance noticeable in an abrupt onset followed by a longer duration than occurs for actual surprise. Often the head will be tilted to the side and the eyes will sharply point away.

Affirmation and negation. Darwin described an affirmation signal among Abyssinians in which the head is thrown back and the eyebrows raised for an instant. Eibl-Eibesfeldt commented also on this signal, particularly among Samoans. He also noted the brow raise as a statement 'no' among Greeks. Our observations in Turkey, where it also signals negation,

suggest that in this case it involves an eyelid movement and sharp upward movement of the head and raising of the chin. Darwin also noted that the Dyaks of Borneo show affirmation with brow raise and negation with the lowering and drawing together of the brows (Action Unit 4) 'with a peculiar look from the eyes' (1872: 274).

Sophisticated skepticism. In Hollywood movies circa 1930–40, sophisticated and attractive women would sometimes employ Action Unit 2 on one side of their face (sometimes with 4 on the other side) to signal sophisticated skepticism. In those days teenagers would try to make this movement, admiring those who could do so. We have rarely seen this movement in any natural situation. This action is used also by villains in melodramas.

These are the only well documented instances of eyebrow emblems – actions which, with other actions, provide unambiguous signals if utilized when people choose to converse without words. Certainly there are other emblems, some involving the face, and many which utilize the hands, but no others in which the eyebrows play a central role.

Let us consider why it is that sometimes people totally unfamiliar with an emblem may accurately describe what it signifies upon first seeing it, for such instances have been incorrectly interpreted as evidence of universality. In emblems the relationship between an action and what it signifies is often iconic, so that the form, rhythm, or what the action does, resembles the message it stands for. Such emblems can be interpreted without any previous familiarity. There are also emblems which appear to be arbitrarily coded, with no obvious relationship between the appearance of the movement and what it signifies. These arbitrary emblems may have little meaning to people outside the social group who customarily employ them. Yet even such an arbitrary emblem may be understood by an outsider if it is placed within a social context where the norms about what is transpiring are so explicit as to suggest what any signal in that locus would mean. We have found it possible for Americans totally unfamiliar with the flash to understand that it signals a greeting, if we place the flash within the context of first response upon noting the presence of a familiar person – precisely where we ordinarily would put a hand-wave emblem.

We and our students have used a standardized method for surveying the repertoire of emblems in five cultures. Our findings agree with Efron's prediction that for the most part these actions are not shared among groups who have not had contact. In the final section, when we consider the origin of the facial social signals, we will suggest that, while

not universal, the use of the eyebrows in some of these emblematic conversational signals is not arbitrary.

Our descriptions of conversational eyebrow signals reveal that two of the eyebrow actions are used again and again: 1+2 and 4. Let us inquire why these actions, rather than any of the other five eyebrow actions, occur in so many conversational signals. These two actions represent the extremes in how the brows can be moved, from raised high to lowered and drawn together. While the research has not yet been done, we expect studies would show that these two actions are the most visually contrasting for the perceiver, the most easily distinguishable of the seven eyebrow actions. The next most contrasting actions are probably 1+4 versus 2+4 which angle the brows up or down in opposite directions. Action Unit 1 may often be confused with 1+4 or with 1+2; 2 may not be easy to distinguish from either 1+2 or 2+4, and the combination of 1+2+4 is probably often confused with 1+2, 4 or 1+4. If research bears out these predictions, then the observation that 1+2 and 4 are the eyebrow actions most often recruited as conversational signals would fit with the hypotheses that the most contrastive actions are selected to become signals.

These two eyebrow actions also differ from the other five brow actions in being the easiest to perform. While a few people seem unusually gifted in being able to move voluntarily any facial muscle, our efforts to teach people to do so suggests – in agreement with Duchenne (1862) – that some facial actions are easier to perform than others. Gowen Roper (1977) has recently completed a developmental study on this topic, using our methods to define and measure facial actions. He asked children of six, nine and thirteen years to imitate a series of facial Action Units and combinations depicted on motion picture film. His results confirmed our prediction: 1+2 and 4 were successfully performed by the majority regardless of their age, while the other five eyebrow actions were successfully performed by less than one-third of the children even at the oldest age.

It is tempting to suggest that 1+2 and 4 are recruited into conversational signals, in part, because they are the easiest to perform. Of course the data do not prove that. They might be the easiest to perform just because they are prevalent social signals. We believe that differences in ease of performance could be shown to predate the use of these eyebrow actions in conversational signals. But there is no evidence as yet to suggest that we are correct in attributing such differences to the neural basis of facial actions rather than to social learning.

Even if such evidence existed, we would only be able to say that the eyebrow actions which are most often employed as conversational signals are the easiest to do and the most visually contrasting. These factors would not explain why one action rather than the other is deployed in a particular social signal. For example, why is 4 not commonly used in greetings, only 1+2? Similarly, why does there appear to be some negative implication in the conversational context when 4 is used rather than 1+2 as a baton, underliner, or question mark? To address this question we will consider the origin of facial actions; but first let us discuss the rationale for distinguishing conversational from emotional signals.

Distinguishing between emotional and conversational facial signals

It may seem strange or artificial to have divided facial movements into emotional and conversational signals. Both occur in the presence of others, both occur during conversation, and some writers have argued that the facial expressions evolved specifically for their role in communication. Let us now consider some differences between these two classes of facial social signals.

The emotional expressions are coherent, organized and systematic in their occurrence earlier in life than most of the conversational signals. Just how early an organized pattern of facial actions can be considered to be emotional is a subject of some argument. For our purposes here we need not be concerned with whether the emotional expressions appear in the first, fifth, or the twelfth month of life. They occur before language and before the emergence of symbolic processes. While some of the conversational signals appear early, not many do. By definition the speaker conversational signals cannot appear before at least the rudiments of intentional spoken language. (There may be precursors of such facial speaker conversational signals as Trevarthen has suggested (chapter 8.2 below) for hand movements.) The listener responses probably do not occur with much regularity very early in speech acquisition, if we define a listener response as one that reflects an understanding of the meaning and syntactic structure of the speaker's words. Dittmann observed that the agreement listener responses are infrequent at age five. (Of course, the child may show attention to the parent's speech much earlier.) While a few emblematic conversational signals may develop prior to speech, the repertoire is limited. For the most part emotional expressions precede conversational facial signals.

The difference in the age at which these two classes of social signals

appear implies something about a difference in the neural mechanisms which direct each set of signals. We hypothesize that diseases and lesions which impair voluntary facial action will also tend to impair the conversational facial signals more than the facial expressions. The social control of the facial expressions through display rules also may show impairment in such cases. And the converse should be so; disorders which impair spontaneous expression but not voluntary facial action will not be accompanied by as many deficits in the conversational facial signals as in the emotional expressions. While this is probably an oversimplification, we are proposing different, if overlapping, neural mechanisms in the direction of these two signal systems.[13]

Such a difference in neural mechanisms would be consistent also with hypothesized differences between emotional and conversational facial signals in the ease with which a person may interfere with each. Some people appear to easily control facial emotional expressions, but most find it a struggle. Some conversational facial signals are so habitual that a person must concentrate to prevent them, yet we think it is easier to interfere with these than the emotional expressions.

Conversational facial signals and emotional expressions differ also in their accessibility to voluntary performance. The conversational facial actions we described are easy to perform; not so with all the emotional expressions. Furthermore, the performance of the conversational or emotional actions has very different consequences. A person can elect to make a conversational facial signal, to utilize even one he has never previously employed. By the performance he succeeds in producing the phenomenon – a greeting has been made, a word or phrase emphasized, a question indicated, etc. Tomkins (1962–3:I) drew attention to how the performance of a facial action or pattern of facial actions does not produce the phenomenon of which it is a part. We cannot so easily generate our own emotional experience. Making an emotional expression if done correctly may fool someone else, but rarely would produce the experience of the emotion.[14]

The referents for the emotional expressions and conversational signals also differ. Earlier we described some of what we mean by emotion, what

[13] Myers agrees with this extrapolation based on his studies, as does Tomkins (personal communication, 1977), who wrote extensively about the complexities of voluntary and involuntary facial expressions.

[14] Because Tomkins emphasized the centrality of the face in his account of emotion, some have misunderstood him on just this point, leading to studies and even therapeutic efforts which have tried to show if you move the muscles you experience the emotion. Tomkins (personal communication, 1977) views this as a fundamental misinterpretation of his theory.

these facial actions signify. It is considerably more complex than what is signified by most conversational facial signals. The emblematic conversational facial signals (those which can be employed when people choose to communicate without words) may refer to simple or complex matters; they are not constrained to just the package of information signified by the emotional expression.

There are a series of differences between emotional and conversational facial signals which have to do with when each is shown. It is rare for conversational signals to occur when a person believes himself unobserved, although they may occur in rehearsals or replays of an encounter. We and other hidden observers have found that emotional expressions occur with regularity when a person thinks he is unobserved. Both types of facial signals occur during conversation, but are related to different aspects of the conversation. Earlier we suggested a number of very specific ways in which the speaker and listener conversational facial signals are related to the words spoken. The emotional expressions during conversation are more related to the affective content of what is said or implied. They also occur in conjunction with the speaker's or listener's feelings about the process of conversing. For example, they may show anger at not finding a word, excitement in speaking fluently, fear of not understanding what is being said, etc. When the emblematic conversational social signals occur in conversation they may repeat, precede or be simultaneous with a spoken word. Sometimes they replace a word, often at the beginning of a conversational turn.

The actual facial behavior may also differ, even when the same Action Units are recruited. For example, when 1+2 occurs as part of an emotional expression, we expect the onset, duration and offset to differ from when it is used as a baton or underliner. Also, if it is an emotional expression it is more likely that it will be accompanied by a specific set of other facial actions, simultaneous or consequent, than if it is a baton or underliner.

The only difference between emotional and conversational facial signals about which there is much evidence is universality. This is, we believe, well established for the emotional expressions – if differences due to display rules and elicitors are taken into account as described above. While the conversational facial signals have been much less studied, what is known suggests they are more widespread than simply an arbitrary use of facial action might suggest, but there are probably no universals.

Admittedly the distinction between emotional and conversational social signals is not always clear cut. We may have misclassified certain conversational signals; for example, research may show that the word

search facial signal (Action Unit 4) should be considered an emotional expression of perplexity. While the distinction must be considered as only provisional, we find it useful since it draws attention to a series of differences which can be investigated. Now let us consider a fundamental issue about both the emotional and conversational facial signals – why some actions rather than others are recruited into particular signals.

The origin of facial social signals

We have described consistencies in the particular facial actions employed in particular social signals. In the emotional expressions, five of the seven eyebrow actions play a role in one or another emotion. Here we ask why they have been 'selected' for their particular role, i.e. what is the nature of the selection process? How can we explain why 1+2 is used in surprise rather than 4, why is 1+4 rather than 2+4 employed in sadness? Parallel questions can be asked about the participation of the eyebrow actions in the conversational signals, for here too consistency was noted. Why is 1+2 rather than 4 employed in a greeting, why is there a (hypothesized) negative implication if 4 is the baton or underliner rather than 1+2?

Most of those who have considered this question (Andrew 1963, Darwin 1872, Eibl-Eibesfeldt 1970) focused only on the emotional expressions. According to these investigators the facial actions seen in emotional expressions originally served some purely biological or instrumental function in our progenitors. In addition, these actions conveyed information to others about an individual's possible future behavior, or what might have happened to elicit the action. Because this (at first incidental) communicative value was also adaptive, the facial actions were maintained in the repertoire even if the original function was lost, or the facial actions were modified as a result of natural selection, to enhance their efficacy as signals.

Ethologists use the term *ritualization* to describe the process by which a behavior is modified through genetic evolution to enhance its efficacy as a signal. If we ask why 1+2 rather than 4 is shown as part of the expression of surprise, an evolutionary explanation might go as follows: the 1+2 may have been adaptive for our progenitors in dealing with unexpected events. This action was maintained in the repertoire and modified to become a better signal because the ability to communicate surprise had survival value for both sender and receiver. Note that ritualization does not imply that the 1+2 action is still adaptive (other than in terms of communication), but only that 1+2 may have been selected for this signal

rather than another action because 1+2 was adaptive for our progenitors. Those who have employed the concept of ritualization to explain the origin of facial social signals have attempted to buttress their argument by postulating a present adaptive value for these facial actions in *Homo sapiens*.

We will review the various claims that have been made about the adaptive value of different eyebrow actions. While many of the claims that have survived in the literature are not supported by current knowledge, some of these brow actions do seem to serve some biological function apart from communication. This possibility opens the door to an alternative explanation to ritualization, one which emphasizes ontogenetic development rather than genetic evolution.

The adaptive value of 1+2. In discussing this action all commentators have emphasized that it increases visual input. Some have more specifically noted that this movement increases the superior portion of the visual field. Blurton Jones and Konner (1971) found that children show this action in visual search and when looking upwards at an adult, although children show 1+2 on other occasions as well. Peiper (1963) pointed out that when a newborn's head is bent forward strongly, 1+2 is part of a reflexive response, together with eye opening and neck movements.

The 1+2 action does increase the superior visual field, yet this influence of 1+2 is probably not uniform for all members of our species. The benefit of 1+2 would depend upon how deeply set the eyes are in the bony socket, the prominence of the brow ridge, and how well endowed with hair the eyebrows are. Generally, there should be more benefit for males, Caucasians, and adults,[15] although obviously there will be individual differences as well.

A number of other related functions of 1+2 have been described which are not supported by current knowledge of the neuroanatomy of vision.[16] Darwin wrote that 1+2 helps to raise the upper eyelid quickly, and raising the upper eyelid helps to increase vision. There is no reason to believe that speed of upper lid action is enhanced by 1+2 unless the person has enormously drooping eye-cover folds, which hang down so far as to place pressure on the upper eyelid. Furthermore, the upper eyelid rarely comes down so far as to block vision unless the person is nodding off to sleep, or *orbicularis oculi* has been contracted. Darwin noted that when someone

[15] Oster suggests that infants' eyes are not deeply set and brow hair is sparse, so 1+2 should have less benefit.

[16] I am grateful for the help of Ed Engle, University of Kentucky, for his advice on how muscle actions influence vision and for directing me to literature on this topic.

becomes drowsy, he may use 1+2 to counteract the involuntary relaxation of the upper eyelid. This could provide the basis for a learned association between 1+2 and wanting to see. Less plausibly, Darwin suggested (and Andrew repeated) the idea that 1+2 helps to free the eyeball so that it can be moved around more quickly.

The adaptive value of 4. In explaining the origin of 4 in emotional expressions Darwin listed many different functions. Most now seem to be incorrect. The two functions which he correctly described he considered unimportant.

Action Unit 4 can act as a sunshade. It is often shown by people subject to bright glaring light, who don't have sunglasses. 'It seems probable that this shading action would not have become habitual until men had assumed a completely upright position, for monkeys do not frown when exposed to a glaring light' (Darwin 1872: 226). Action Unit 4 decreases the superior visual field, the extent of influence depending on the variables mentioned earlier with respect to the value of 1+2 in increasing the superior visual field. Since mental activity and vision are closely related Darwin thought this use of 4 to decrease light and narrow the field of view explained why we come to use 4 whenever we encounter something difficult. Since Darwin, a number of writers have supported his observation (often without crediting him), finding that 4 occurs during concentration, determination, or when difficulty of some kind is encountered. Oster (1978) reports what seems to be a precursor of 4 in concentration in one to three month old infants gazing at their mothers' faces.

Another explanation, mentioned but considered unimportant by Darwin, was that 4 helps to protect the eyeball from blows. Neither he nor anyone else has made much of this possibility, although it is undoubtedly true, even if 4 may afford little such protection.

Darwin placed greatest emphasis on Bell's (1872) claim that 4 along with *orbicularis oculi* serves to protect the eyeball from becoming engorged with blood during violent expirations in screaming, crying, etc. Lersch (1932) and Peiper (1963) were doubtful of this. This explanation has survived and continues to appear in accounts of the basis of facial expression. Current understanding of the eye suggests that Bell was wrong. It is plausible, but not proven, that *orbicularis oculi* could by mechanical pressure on the eyeball sufficiently increase the pressure of the vitreous fluid to counteract vasodilation. But even if *orbicularis oculi* does serve this protective function, there is no need for 4 to be involved. *Orbicularis oculi* and the muscles involved in 4 can and often do act independently. In fact,

Darwin noted that 4 often precedes *orbicularis oculi* before infants begin to cry. By itself, however, 4 cannot exert any pressure on the eyeball and thus cannot protect the blood vessels in the eyes. In sum, while Darwin was correct in observing that 4 is virtually always present in crying, along with extreme *orbicularis oculi* contraction, his explanation of what function it serves fails.

Darwin mentioned another explanation of the origin of 4 which he attributed to a famous specialist on optics, Dr Donders. The muscles involved in 4, along with the action of *orbicularis oculi*, were said to cause the eyeball to advance 'in accommodation for proximity', converging the optical axes. Darwin did not emphasize Donders' idea in his account of the origin of 4, although Andrew did. Neither 4 nor *orbicularis oculi* can advance the eyeball. In any case, the eyes do not focus by advancing the eyeball but by changing the shape of the lens and cornea. Squinting, caused by a strong action of *orbicularis oculi*, can help to sharpen vision by exerting pressure on the cornea, but again this action need not involve 4, and 4 alone could not have any effect on sharpening vision. A related idea was put forward by van Hooff (1969). The muscles involved in 4 were said to steady the eye in visual fixation. If facial muscles could so steady the eye, it would be *orbicularis oculi*, not 4, that would do so.

The adaptive value of 1+4. Based on Duchenne's (1862) observation that the muscles involved in 4 are difficult to inhibit, Darwin offered an explanation of the 1+4 in sadness. When we learn to inhibit crying, the only way we can counteract the involuntary involvement of *depressor glabellae* which lowers the inner portion of the brows is by the upwards counterforce of Action Unit 1. However, the *corrugator* muscle which draws the brows together cannot be prevented from acting by Action Unit 1. As a result, we see the combined action of strongly drawn together brows raised at their inner ends – 1+4. This is a clever explanation, and may be true. It builds upon the involvement of 4 in crying, which though not to be doubted, itself is not explained. Moreover, it has not been demonstrated that contraction of Action Unit 1 in expressions of sadness represents a voluntary effort to control crying. No one else has even discussed the origin of 1+4 in sadness.

The adaptive value of 1+2+4. No one has speculated about the origin of this facial action in fear, so we will mention two possibilities. Perhaps this eyebrow action should be considered the consequence of merging two actions seen in other primates during threat: 1+2 and 4. Alternatively, if

we consider fear as an anticipatory response, it might make sense to explain 1+2+4 as a movement relevant to attention and increased visual input (1+2), occasioned by a novel object, with 4 providing the clue as to what is anticipated, a distress experience. Considering fear as an anticipation of distress is consistent with the thinking of most developmental psychologists who believe infants do not show fear until late in the first year of life when they develop the cognitive abilities necessary to anticipate. The viability of this explanation awaits longitudinal study of the occurrence of 1+2+4 in fear situations.

To *summarize* this review of the adaptive value of the eyebrow actions, 1+2 and 4 have opposite effects on vision. The former increases and the latter decreases the superior visual field. In addition, 1+2 may make the eyeball more vulnerable to blows, cinders, and the like while 4 may afford some protection.

Even though some of the claims for the adaptive value of 1+2 and 4 no longer seem credible, these facial actions do seem to have opposite effects on vision and these effects can be used as the basis for an explanation of their role in emotional expression. Presumably 1+2 is the action involved in a surprise expression rather than 4 because 1+2 increases visual input. Similarly (although less convincingly), 4 is involved in an anger or distress expression because this action protects the eyeball from blows, decreases glare, and decreases visual input.

By this logic the selection of 1+2 and 4 for their respective signals could have been the product of genetic evolution (ritualization) or through a process of learning (what Smith (1977) calls conventionalization). Two problems weaken the ritualization explanation.

1. Ritualization presumes that selection of actions for their role as signals occurred through phylogenetic evolution. The implication is that these signals can be traced to other primates, i.e. they do not exist *de novo* in *Homo sapiens*. One might expect to see 1+2 in contexts of surprise and 4 in anger in other primates. Chevalier-Skolnikoff's (1973) and Redican's (1975) reviews, and study of some of the literature they cite, suggest that the matter is ambiguous. In threat, for example, some primates show both 1+2 and 4. No one, to our knowledge, has yet done the type of analysis which would reveal whether something different is happening within a threat episode when those two actions occur, although Redican suggested that possibility. Furthermore, we are not certain whether the actions of 1+2 and 4 have the same influence on vision in other primates as they do in humans, although non-human primates do have the muscular equipment to raise and lower the eyebrows. The prominence of the

eyebrow ridge may lessen the influence of these actions on vision in some species.

Some might argue that we should not expect to be able to trace the origin of facial actions to other primates, yet wide credence is given to just such an account of the smile by van Hooff (1971). The lack of evidence regarding homologous eyebrow actions in non-human primates does not rule out an evolutionary account of the role of these actions in emotional expression, although the presence of such evidence would be supportive. By raising this issue perhaps we can encourage primatologists to examine these eyebrow actions in more detail, for the evidence might be there.

2. Implicit in the assertion that facial expressions are innate species-specific signals (cf. chapter 1.1 above) is the assumption that they were shaped into specialized communicative signals by the process of natural selection; i.e. that their function as signals is innate and cannot be explained on the basis of some purely biological function in present-day *Homo sapiens*, either in adults or in children. Yet those eyebrow actions for which we can specify an adaptive function (1+2 and 4) continue to serve this function for contemporary man (as noted by Allport 1924, Blurton Jones 1971, Lersch 1932, Peiper 1963). The fact that these actions have current adaptive value allows for the *possibility* that ontogeny may play more of a role than phylogeny in shaping these actions into expressive signals. The genes may transmit only information about how the equipment works (1+2 increases the visual field). The signal value of such an action and its association with emotion (surprise) may depend primarily upon early experience, experience common to all members of the species who have a functioning visual apparatus.

Such reasoning would go as follows:

> Infants encounter unexpected events in which they would raise their brow to see what is happening above them. (One could even argue that the unexpected is more likely to be above than below the infant.) Over time, perhaps abetted by the signal value of the movement, brow raising and surprise would become associated. In the strictest version of this explanation, the infant would have to learn, presumably by trial and error, that brow raising increases his visual field. Alternatively, that might be given, and what he learns is to make this movement when trying to see what has unexpectedly happened. To grant even more to biology, the infant could be born equipped to raise his brows when visually scanning unexpected sudden visual events. What he needs to learn is to generalize this response to any unexpected event, regardless of whether it is visual. (Ekman 1977b)

We do not mean to suggest that this type of species-constant learning *is* the correct explanation, only that it is just as plausible as an explanation

based on phylogenetic evolution. There is no clear evidential base for making a choice between conventionalization (species-constant learning) and ritualization (phylogenetic evolution) in explaining the role of eyebrow actions in emotional expression. The origin of 1+2 in surprise could be resolved by developmental data. If blind infants do not show 1+2 to sudden unexpected sounds or touches, then at least we could assume that the brow raise is not wired in for surprise, nor for scanning, if the eyes are not operative. Unfortunately, that data is equivocal (cf. Charlesworth 1970, Eibl-Eibesfeldt 1972, Lersch 1932, Goodenough 1932, Peiper 1963). No one has yet done a detailed descriptive study of the repertoire of facial behavior in the first year of life, for either blind or sighted infants.

The role of Action Unit 4 in both anger and distress is similarly open to multiple interpretations. There is no evidence as yet to rule out the possibility that species-constant learning experiences are decisive, with phylogenetic evolution contributing only the basic biological function (4 narrows the visual field and protects the eyeball). A conventionalization explanation for this action in distress seems less plausible, but the choice between explanations should rest upon data, not just plausibility.

Now let us consider a different type of problem with explaining the origins of facial actions as instances of ritualization. This view stresses the biological adaptive value of these actions for our progenitors. This explanation does not apply to three of the eyebrow actions: 1 and 1+4 in sadness, and 1+2+4 in fear – since it is not possible to show (or at least no one has shown) a biological function for these actions for humans or to imagine one for our progenitors. It might be argued that it is not necessary to find specific adaptive value for each of the eyebrow configurations. Rather, once certain actions became part of the behavioral repertoire via their adaptive value (1+2 and 4), they could have been shaped by evolution into specialized displays. The new communicative function of 1, 1+4 or 1+2+4 need not be linked to any purely biological function. While we would be more satisfied to find some plausible phylogenetic scenario to explain why 1+2+4 occurs in fear and 1+4 in sadness rather than vice versa, this is not necessary, one might argue. Darwin's principle of antithesis might be invoked here, but if it is we should be able to demonstrate how a given action is antithetical to another. Here again, data on these actions in non-human primates, and on their ontogeny in blind and sighted infants, would help to clarify the matter.

We have been discussing the origins of the facial actions in emotional expressions. Now let us consider the origin of the facial conversational signals. For those that involve 1+2 more than 4, and vice versa, it seems

most conservative to assume that the selection of one or another action is based upon socio-cultural or ontogenetic processes (conventionalization) rather than on natural selection. If the selection were exclusively or largely the result of phylogenetic evolution, the actions employed in these conversational signals should be more uniform across cultures than we believe the evidence suggests. The socio-cultural or ontogenetic processes might be based either on the role of these actions in emotional expressions, or on the adaptive consequences of these actions for humans.

It could be said that 1+2 as a component of surprise (which entails unexpected, novel, sudden events and likely orientation towards the source), is a more sensible candidate for a greeting than 4, which is seen in anger or distress. Certainly the connotations of 1+2 should be less disruptive of greeting than would be the connotations of 4. With respect to the use of 1+2 or 4 as batons or underliners, such reasoning would suggest that 4, which is employed in a variety of negative emotions (fear, sadness, distress, anger) should carry an implication of something negative, whereas 1+2 would be more likely to suggest surprise or interest. Alternatively, the role played by these two actions in conversational signals may be selected on the basis of their current biological function: 1+2 increasing and 4 decreasing visual input. Their role in conversational signals would thus be viewed as analogues to their biological adaptive value. Either possibility could be true. Careful description of facial actions in longitudinal studies of blind and sighted infants extending through the point in childhood where these actions appear as conversational signals is needed to resolve the issue. Relevant also would be study of the occurrence of conversational as compared to emotional facial signals in individuals suffering from lesions in different brain areas.

We do not mean to deny the likelihood that evolution played a major role in emotional expression. This must be the case for at least some facial actions in some of the facial expressions of emotion. But which ones, and on what basis, is not known. Certain facial actions may have served a crucial adaptive function in our evolutionary precursors or during ontogenetic development. Species-constant learning may be important in explaining some facial expressions, certainly not all. (Smiling is an example of an expression which cannot be explained by species-constant learning.) Again, with few exceptions we do not know which ones. The problem with accepting ritualization as the explanation of the origin of facial social signals at this point in our knowledge is that it forecloses investigation of issues which should be explored, it leads away from

rather than toward research which needs to be done. Competing explanations should be considered and ambiguities emphasized to motivate the research which is needed on facial social signals.

Conclusion

By focusing just upon the eyebrows we were able to demonstrate how an anatomically based descriptive system provides a powerful tool for distinguishing among facial movements. Hundreds of visibly different facial actions occur, and thousands are possible. Yet, each can be recognized and described using our *Facial action coding system.*

The questions that we raised about the origin of both emotional and conversational signals involving the eyebrows can and should be raised about other facial actions. We believe such consideration will reveal similar ambiguities, and point to the type of research which is needed. The distinction between emotional and conversational signals applies to the entirety of facial action, not just the brows. While the brows play an important role in conversational signals, we expect that study will show some conversational signals using the eyelids and movements around the mouth.

The student of emotional expression needs to understand the conversational signals as well. These actions occur often and if they are not recognized will confuse the study of emotional expressions. The student of conversation must understand the emotional expressions if he is to disentangle them from actions that are directly guided by conversational processes. Further, the particular facial action employed in a particular conversational signal (e.g. in batons, underliners, question marks, etc.) may be related to the role played by that action in emotional expression. The student of human communication will, of course, want to understand the full complexity of behaviors which provide social signals, including both emotional and conversational facial signals, as well as body movement and speech.

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