The mechanism of human facial expression

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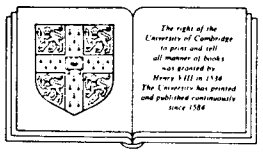

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4. Duchenne and facial expression of emotion

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> Armed with electrodes, one would be able, like nature herself, to paint the expressive lines of the emotions of the soul on the face of man. What a source of new observations![1]

It is only recently that I had the pleasure, through Andrew Cuthbertson's translation, of being able to read Duchenne's book with ease. Because of my rusty college French, my initial introduction to Duchenne was selective. My access to Duchenne had been aided by Harriet Oster, a postdoctoral fellow working with me in the early 1970s. With her background in French literature, and an interest in measuring facial behavior, Harriet carefully checked Duchenne's description of the muscles responsible for particular changes in facial appearance. I was then, with my colleague Waly Friesen, deeply immersed in constructing a tool for measuring facial behavior based on the anatomy of facial movement. Duchenne's book was an invaluable resource. His identification of the particular muscles producing specific changes in facial appearance provided the groundwork for those who measure facial behavior today. Duchenne's study of the mechanics of facial movement and the objective assessment of facial activity are, therefore, of great historical importance.

Most recently I have become fascinated by Duchenne's ideas on the nature of facial expression of emotion, having been quite unfamiliar with some of them until reading the translation in full. The photographs made by Duchenne provided, as he says in the quote above, a rich basis for observations.

Universality

Duchenne simply asserted:

> In the face, our Creator was not concerned with mechanical necessity. He was able, in his wisdom, or – please pardon this manner of speaking – in pursuing a divine fantasy, to put any particular

[1] Duchenne, G.B.A.: *Mechanism of Human Facial Expression*, p. 9, this volume.

> muscle in action, one alone or several muscles together, when he wished the characteristic signs of the emotions, even the most fleeting, to be written briefly on man's face. Once this language of facial expression was created, it sufficed for him to give all human beings the instinctive faculty of always expressing their sentiments by contracting the same muscles. This rendered the language universal and immutable.[2]

It is only recently that evidence for the universality of certain facial expressions of emotion has been obtained[3] and there are still some anthropologists who reject such a claim.[4] Of course, the current explanation of universality is based on evolution, not our Creator. Charles Darwin, in his copy of Duchenne's book, put an exclamation mark in the margin next to the section I have just quoted. Darwin then wrote in the margin:

> Good to show how theory fails. Praise his book, well known for other excellent treatises and adds much. In my opinion, by [compared to?] other writers a vast step in advance.[5]

Character and facial appearance

People have long believed that they could derive information about personality or character from the face, usually based on physiognomy. While such interpretations of the size and shape of the facial features was respectable in the eighteenth and nineteenth centuries and continues to reappear in popular books today, it has no scientific credibility. Duchenne offered another possible means – apart from physiognomy – by which character might be revealed in facial appearance.

> In the newborn, the soul is bereft of all emotion and the facial expression at rest is quite neutral; it expresses the complete absence of all emotions. But, from the time that the infant can experience sensations and starts to register emotions, the facial muscles portray the various passions on his face. The muscles most often used by these early gymnastics of the soul became better developed and their tonic force increases proportionately.

[2] Duchenne: *op. cit.*, p. 19, this volume.

[3] For a recent review see Ekman, P.: The argument and evidence about universals in facial expressions of emotion. In *Handbook of psychophysiology: the biological psychology of emotions and social processes*. H. Wagner and A. Manstead (Eds.), London: John Wiley Ltd., 1989.

[4] Lutz, C., and White, G.M. (1986): The anthropology of emotions. *Annual Review of Anthropology* 15:405.

[5] I am grateful to Andrew Cuthbertson for giving me Darwin's comments on Duchenne's book, which I draw upon here and elsewhere in this chapter. This copy is in the Cambridge University Library, where access was kindly provided by Mr. Peter Gautrey.

> The face in repose must undergo some modification by the tonic force of these muscles . . . [to] be the image of our habitual sentiments, the *facies* of our dominant passions.[6]

Birdwhistell made a similar suggestion, although he did not cite Duchenne.[7] No one has seriously studied this matter using facial electromyography, in either longitudinal or cross-sectional developmental studies, to relate measures of emotion to any particular pattern of maintained facial muscle tonus. One of the problems with Duchenne's theory is that it presumes the facial muscles to be a dedicated system for emotion. My own studies[8] suggest that even in highly emotional situations, emotional facial expressions are outnumbered by facial actions that regulate the flow of conversation and illustrate speech as it is spoken. I have called these facial movements *conversational signals*. If there are changes in facial appearance due to usage, they will have to reflect the type of conversational signals deployed, not just the frequency of specific emotional expressions.

Perception of faces

Unlike his assertion of universality in expression, Duchenne provided evidence for his observation that the movement of a single muscle could create the impression that the entire expression had changed.

> From early in my research I had noticed that the isolated contraction of one of the muscles moving the eyebrow always produced a complete expression on the human face.[9] [Duchenne goes on to explain that at first he thought this was due to a reflex action spreading the effect across other muscles, until he made a lucky discovery.] And then a fortunate accident occurred that showed me that I had been the victim of an illusion. One day I was exciting the *muscle of suffering* and at the moment when all the features appeared to be contracted expressing pain, the eyebrow and the forehead were suddenly masked (the veil of the person on whom I was experimenting falling over her eyes). Imagine my surprise in seeing that the lower part of the face was not displaying the least contraction!

[6] Duchenne: *op. cit.*, p. 31, this volume.
[7] Birdwhistell, R.L. (1970): *Kinesics and context*. Philadelphia: University of Pennsylvania Press.
[8] Ekman, P. (1979): About brows: Emotional and conversational signals. In *Human ethology*. (M. von Cranach, K. Foppa, W. Lepenies, and D. Ploog, Eds.). Cambridge: Cambridge University Press, p. 169.
[9] Duchenne: *op. cit.*, p. 13, this volume.

> I repeated this experiment several times, covering and uncovering the forehead and the eyebrow alternately; I repeated it on other subjects, and also on a fresh cadaver, and always got identical results. That is to say, I saw complete immobility of the features of those parts of the face below the eyebrows; but at the instant the eyebrows and the forehead were uncovered, so that one could see the whole facial expression, the features of the inferior part of the face seemed to take on an attitude of suffering.[10]

In his book on expression, Darwin commented on this discovery by Duchenne, including it in his list of reasons why it is so diffuclt to study expression.[11] More than a hundred years later, before being aware of Duchenne's discovery, we rediscovered and illustrated this point.[12]

Figure 1 a&b
"[The figure] reveals something else that is very important when looking at facial expressions. Patricia [the name of the model] seems to show doubt or questioning across her entire face; but this is a composite photograph. The brow is the only part of the face that has been changed from the neutral picture on the left. If you cover the brow with your hand, you can see that this is so. With many facial expressions a change in just one area gives the impression that the rest of the facial features have changed as well."[13]

[10] *Ibid.*, p. 13, this volume.
[11] Darwin, C. (1955): *The expression of the emotions in man and animals.* New York: Philosophical Library, p. 13. (Originally published 1872.)
[12] Ekman, P., and Friesen, W.V. (1975): *Unmasking the face: a guide to recognizing emotions from facial cues.* New Jersey: Prentice Hall.
[13] *Ibid.*, p. 39.

Voluntary versus involuntary expressions

Duchenne not only electrically stimulated the face to produce expressions, but he also asked his subjects to make expressions. He discovered that some facial movements are very difficult to make voluntarily. Duchenne noted that one of his most gifted subjects (Plate 4), who could make nearly all facial muscle movements voluntarily, still could not move *m. procerus*, which lowers the skin between the eyebrows. More generally Duchenne claimed that "[t]he muscles that move the eyebrows, of all the expressive muscles, are least under the control of the will; in general, only the emotions of the soul can move them in an isolated fashion."[14]

Darwin considered the identification of those muscles difficult to control voluntarily to be one of Duchenne's most important discoveries.

> He has also, and this is a very important service, shown which muscles are least under the separate control of the will.[15]

Duchenne noted that all of the facial muscle actions would occur involuntarily, but only some could be produced deliberately. This dual control of at least some facial expressions agrees with the modern clinical neurology literature, which describes how lesions may differentially affect either voluntary or involuntary expressions while leaving the others intact.[16,17,18] If the lesion is in the pyramidal system (for example, the precentral gyrus), the patients cannot smile deliberately but will do so when they feel happy. Lesions in the nonpyramidal areas produce the reverse pattern; patients can smile on request, but will not smile when they feel a positive emotion. The pyramidal or voluntary motor pathways are more recent phylogenetically than the extrapyramidal or involuntary pathways.

While current research substantiates Duchenne's general observation that some muscles are more subject to voluntary direction than others, Duchenne wrongly asserted that the eyebrows cannot be controlled voluntarily. He may be correct about *m. procerus* (Friesen and I have never found anyone who voluntarily can produce that muscle's movement), but there are other eyebrow movements (for example, contracting the

[14] Duchenne: *op. cit.*, p. 43, this volume.
[15] Darwin: *op. cit.*, p. 5.
[16] Miehlke, A. (1973): *Surgery of the Facial Nerve.* Philadelphia: Saunders.
[17] Myers, R.E. (1976): Comparative neurology of vocalization and speech: proof of a dichotomy. *Annals of the New York Academy of Sciences*, 280:745.
[18] Tschiassny, K. (1953): Eight syndromes of facial paralysis and their significance in locating the lesion. *Annals of Otology, Rhinology and Laryngology*, 62:677.

entire *m. frontalis*) that everyone can produce voluntarily. Other movements of the eyebrows are difficult for most people to enact voluntarily, for example, raising just the inner or just the outer portions of the brows, but 10 to 20 percent of the population can produce these movements. Duchenne also failed to note other lower facial muscles that few people can move voluntarily (for example, tightening the inner strands of *m. orbicularis oris* or *m. zygomaticus minor*).[19]

Duchenne did note that:

> . . . certain people, comedians above all, possess the art of marvelously feigning emotions that exist only on their faces or lips. In creating an imaginary situation they are able, thanks to a special aptitude, to call up these artificial emotions.[20]

I interpret this quote as suggesting that some people have the theatrical ability to imagine emotional scenes and, when they do so, can produce expressions otherwise impossible when trying voluntarily to move specific muscles. This, of course, fits current thinking about the way actors using the Stanislavski technique retrieve sense memories to generate not just the expression but also the physiology of emotion.[21]

Smiling

Duchenne took matters one step further in asserting:

> But it will be simple for me to show that there are some emotions that man cannot simulate or portray artificially on the face; the attentive observer is always able to recognize a false smile.[22]

That is quite an assertion! Darwin wrote in the margin next to that passage "no evidence." Now, more than 100 years later, there is *some* evidence, but it is not as strong as Duchenne claimed, and differs in some details. Before summarizing these recent findings, let me describe in more detail Duchenne's discussion of smiling, for he was quite specific about how to distinguish the genuine smile of enjoyment from the feigned smile.

> The emotion of frank joy is expressed on the face by the combined contraction of *m. zygomaticus major* (I, Plate 1) and the inferior part

[19] See Ekman, P., Roper, G., and Hager, J.C. (1980): Deliberate facial movement. *Child Development* 51:886, for empirical findings on the development of the ability to voluntarily contract specific muscles.

[20] Duchenne: *op. cit.*, this volume, p. 30.

[21] For recent evidence of this see: Ekman, P., Levenson, R.W., and Friesen, W.V. (1983): Autonomic nervous system activity distinguishes between emotions. *Science*, 221:1208.

[22] Duchenne: *op. cit.*, p. 30, this volume.

> of *m. orbicularis oculi* (E, Plate 1). The first obeys the will, but the second (the muscle of kindness, of love, and of agreeable impressions) is only put in play by the sweet emotions of the soul. Finally, fake joy, the deceitful laugh, cannot provoke the contraction of this latter muscle.[23]

Duchenne described his discovery of the crucial role played by *m. orbicularis oculi* in distinguishing a true from a false smile, in discussing Plates 30, 31, and 32. Of *m. orbicularis oculi,* which produces the movement of the lower eyelid observable in Plate 32, he said:

> [without it] . . . no joy could be painted on the face truthfully . . . [it] does not obey the will; it is only brought into play by a genuinely agreeable emotion. Its inertia in smiling unmasks a false friend.[24]

He further discussed the role of the smile that lacks *m. orbicularis oculi,* recognizing that it can be used simply in politeness or to deceive.

> You cannot always exaggerate the significance of this kind of smile, which is often only a simple smile of politeness, just as it can cover a treason. . . . We, in other circumstances and in normal intercourse with society, politely smile with our lips at the same time as being malcontented or when the soul is sad. When I did the experiment that is the subject of Plate 84, my model was in a very bad mood; her gaze was cold and the corners of her mouth a little lowered (cover on the left side the half of the mouth and the lower part of the cheek). As soon as I had produced the slight contraction of *m. zygomaticus major* on the left (cover the same parts on the opposite side), the false smile of Lady Macbeth in the above described scene [when concealing her plan to assassinate King Duncan], is portrayed on the face.[25]

Darwin substantiated Duchenne's interpretation of these photographs by showing Duchenne's Plates 31 and 32 (reproduced below) to people. Darwin reported that everyone recognized Plate 32 as happiness but Plate 31, in which there was only *m. zygomaticus major* activity without *m. orbicularis oculi,* was not said to be a smile of enjoyment.

In describing how one can recognize the true smile, Duchenne emphasized the effect of *m. orbicularis oculi* on the skin below the eye. Darwin added that this muscle produced changes in raising the upper lip and in slightly lowering the eyebrow.

We found[26] that some of the actions of *m. orbicularis oculi* – for ex-

[23] *Ibid.*, p. 126, this volume. [24] *Ibid.*, p. 72, this volume. [25] *Ibid.*, p. 127, this volume.
[26] Ekman, P., and Friesen, W.V. (1978): *The facial action coding system.* Palo Alto: Consulting Psychologists Press.

Figure 2 A & B

ample, producing the change in the skin below the lower eyelid, raising the cheeks, and the crows' feet wrinkles – were reliable only when the action of *m. zygomaticus major* was slight to moderate. When the smiling action produced by *m. zygomaticus major* was broad, these changes in appearance occurred even without the action of *m. orbicularis oculi.* With the broad smile it was only the lowering of the brow and the change in the appearance of the eye cover fold that remained as a reliable sign of *m. orbicularis oculi* activity.

Our studies of how readily people could voluntarily move each facial muscle[27] suggested a further modification to what Duchenne and Darwin suggested would differentiate the smile of enjoyment from the social or feigned smile. Most people can readily contract the inner portion of *m. orbicularis oculi,* which tightens the eyelids (pars palpebralis), but few can voluntarily contract the outer portion, which raises the cheeks and draws skin from around the eye inward (pars lateralis). We have identified those instances in which *m. zygomaticus major* was accompanied by *m. orbicularis oculi* pars lateralis as the smile of enjoyment. In his honor we have called this *Duchenne's smile.*[28] Duchenne's idea that one could tell from the smile itself whether it was one of enjoyment, or polite or feigned, is supported by recent evidence.

There have been nine studies. Ekman, Friesen, and Ancoli found that

[27] Ekman, Roper, and Hager (1980): *op. cit.*

[28] In an earlier paper (Ekman, P., and Friesen, W.V. (1982): Felt, false, and miserable smiles. *Journal of Nonverbal Behavior* 6:238) we referred to this as a *felt smile.*

Duchenne's smiles occurred more often than three other types of smiles when people watched pleasant films;[29] and only Duchenne's smiles correlated with the subjective report of happiness. Ekman, Davidson, and Friesen[30] also showed that Duchenne's smile, but not other smiling, differentiated which of two positive experiences was most enjoyed. Ekman, Friesen, and O'Sullivan[31] found that Duchenne's smiles occurred more often when people were actually enjoying themselves, as compared with people feigning smiling to conceal negative emotions. Fox and Davidson[32] found that in 10-month-old infants Duchenne's smiles occurred more often in response to the mother's approach, while other types of smiles occurred more often in response to the approach of a stranger; and only Duchenne's smiles were associated with left frontal EEG activation, the pattern of cerebral activity repeatedly found in positive affect. This EEG pattern of cerebral activity associated with Duchenne's smile was replicated by Ekman, Davidson, and Friesen[33] in adults who were watching amusing films. Matsumoto[34] found that depressed patients showed more Duchenne's smiles in a discharge interview compared with the admission interview, but there was no difference in the rate of other kinds of smiling.

The possibility that these differences between types of smiling might be universal was raised in the next four studies, all of which were conducted in Europe. Steiner[35] found that the frequency of Duchenne's smiles, but not other types of smiles, increased over the course of psychotherapy in patients who were judged to have improved. Ruch[36] found that Duchenne's smiles were sensitive to the amount of humor felt by German adults when responding to jokes or cartoons. Schneider[37] found

[29] Ekman, P., Friesen, W.V., and Ancoli, S. (1980): Facial signs of emotional experience. *Journal of Personality and Social Psychology*, 39:1125.

[30] Ekman, P., Davidson, R., and Friesen, W.V. (1989): Duchenne's smile: emotional expression and brain physiology II. Under review.

[31] Ekman, P., Friesen, W.V., and O'Sullivan, M. (1988): Smiles when lying. *Journal of Personality and Social Psychology*, 54:414.

[32] Fox, N.A., and Davidson, R.J. (1988): Patterns of brain electrical activity during facial signs of emotion in 10-month-old infants. *Developmental Psychology*, 24:230.

[33] Ekman, Davidson, and Friesen (1989): *op. cit.*

[34] Matsumato, D. (1986): *Cross-cultural communication of emotion*. Doctoral dissertation, University of California, Berkeley.

[35] Steiner, F. (1986): Differentiating smiles. In *FACS in psychotherapy research* (E. Branniger-Huber and F. Steiner, Eds.). Zurich: Department of Clinical Psychology, Universitat Zurich, p. 139.

[36] Ruch, W. (1987): Personality aspects in the psychobiology of human laughter. Paper presented at the Third Meeting of the ISSID, Toronto.

[37] Schneider, K. (1987): Achievement-related emotions in preschoolers. In *Motivation, intention and volition* (F. Hahseh and J. Kuhl, Eds.). Berlin: Springer.

that Duchenne's smiles distinguished whether young children had succeeded or failed in a game. Krause and Steiner[38] found that Duchenne's smile occurred more often during interviews with healthy subjects than in interviews with schizophrenic patients.

One qualification must be remembered. In all of these studies, Duchenne's smile was distinguished from other smiles by very precise facial measurement using repeated and often slow motion viewing.[39] It is not yet known whether an observer looking at real time can distinguish Duchenne's smile from other smiles.

Interpretation of particular muscle actions

Unlike Darwin, who checked his own impressions by showing photographs to others, Duchenne relied on his own judgment. Often his interpretations have been borne out by recent research findings. Most notable were his judgements that:

- *m. zygomaticus minor* was involved in sadness and pain, not happiness;
- *m. platysma* activity added to the intensity of any negative emotion shown on the face;
- *m. buccinator* signaled irony.

Duchenne also noted that by combining muscular actions, each of which are associated with different emotions, a blend of the two can be created. For example, he described combining a smile with the raising of the inner corners of the eyebrow to create the look of compassion. In recent times, Plutchik,[40] Tomkins and McCarter,[41] Izard,[42] and Ekman and Friesen[43] have all elaborated on this idea of blends, although none cited Duchenne.

Methodological contribution

Duchenne's discoveries using electrical stimulation of the face to determine exactly which muscles produce specific changes in facial appear-

[38] Krause, R., and Steiner, E. (1989): Facial expression of schizophrenic patients and their interaction partners. *Psychiatry*, under review.

[39] Ekman, P., and Friesen, W.V. (1976): Measuring facial movement. *Journal of Environmental Psychology and Nonverbal Behavior*, 1:56; and Ekman and Friesen (1978): *op. cit.*

[40] Plutchik, R. (1962): *The emotions: facts, theories, and a new model.* New York: Random House.

[41] Tomkins, S.S., and McCarter, R. (1964): What and where are the primary affects? Some evidence for a theory. *Perceptual and Motor Skills*, 18:119.

[42] Izard, C.E. (1971): *The face of emotion*, New York: Appleton-Century-Crofts.

[43] Ekman, P., and Friesen, W.V. (1969): The repertoire of nonverbal behavior: catagories, origins, usage, and coding. *Semiotica*, 1:49.

ance provide the basis for contemporary facial measurement in the behavioral sciences. To understand the nature of his contribution I will briefly describe the different approaches to measuring facial behavior and then the role of Duchenne's discoveries in current work.

There are two approaches to studying any aspect of nonverbal behavior[44,45,46]: measuring judgments about one or another message and measuring the sign vehicles that convey the message. Take for example the question of whether facial expressions vary with psychopathology. Suppose a sample were available of facial behavior during interviews with patients who have a diagnosis of schizophrenia or depression and with a control group displaying no psychiatric problems. To use the *message judgment* approach, the facial movements in these interviews would be shown to a group of observers, who would be asked whether each person they viewed was normal, schizophrenic, or depressive. If the judgments were accurate, this would answer the question. In using the *measurement of sign vehicles* approach, some or all of the facial movements somehow would be classified or counted. If we found, for example, that depressives raised the inner corners of the eyebrows more than the other two groups, whereas schizophrenics showed facial movements that very slowly faded from the face, this would answer the question affirmatively. The measurement of sign vehicles approach tells us about differences in facial behavior, but it cannot tell us whether observers (who are not using a measurement technique) can recognize those differences. Conversely, the message judgment approach would tell us that observers can recognize differences in facial behavior, but it would not tell us what those differences might be.

Both approaches are useful, but only by measuring the sign vehicles, the facial activity itself, can we learn which facial actions provide information. Until 10 years ago there were relatively few studies measuring facial behavior. There was no objective, comprehensive tool for making such measurements. Each scientist started anew, rarely making use of the work of predecessors.

Every investigator proposed a list of facial actions such as brow raise,

[44] Ekman, P. (1964): Body position, facial expression and verbal behavior during interviews. *Journal of Abnormal and Social Psychology*, 68:295.

[45] Ekman, P. (1965): Communication through nonverbal behavior: a source of information about an interpersonal relationship. In *Affect, cognition and personality* (S.S. Tompkins and C.E. Izard, Eds.). New York: Springer, p. 390.

[46] Ekman, P. (1982): Methods for measuring facial action. In *Handbook of methods in nonverbal behavior research* (K.R. Scherer and P. Ekman, Eds.). New York: Cambridge University Press, p. 45.

nose wrinkle, lip corners down, and so on. Measurement included noting the presence of any action or combination of actions, when they began and ended, and their strength. The question has been what to put on the list of facial actions, how an investigator, confronted by the complex flow of facial activity, decided upon what to put on the list of facial behaviors to score.

One investigator[47] tried to select facial behaviors to parallel linguistic units. Another proposed a list based on the function of each action.[48] However, most of these lists have been incomplete and imprecise. Most authors described facial actions by changes in the shape of the features and the appearance of wrinkles, disregarding the anatomical basis for these changes. Often these descriptions were vague and unable to deal with individual differences in appearance and differences associated with age.[49]

I started by listing those facial actions that theory or findings suggested were relevant to one or another emotion,[50] trying to achieve precision by photographically, rather than verbally, depicting each action on the list. I learned from Wade Seaford, an anthropologist who had studied facial anatomy,[51] that we had inadvertently left out the raising of the lower lip due to *m. mentalis*. This convinced me that the only way to build a tool for measuring facial behavior comprehensively was to base the list of actions on the anatomy of facial movement.

The anatomy texts provided relatively little description of how each muscle changes appearance. As Washburn pointed out,[52] the sections on the face in most anatomy texts was a dead, rather than a live, anatomy, naming muscles as one sees them when the skin has been removed, rather than classifying muscles by their action. Duchenne had discovered 100 years before:

> Anatomy has grouped some muscles under the same name that possess independent actions when electrically stimulated . . .[53]

[47] Birdwhistell, R.L. (1952): *Introduction to kinesics*. Louisville, Kentucky: University of Louisville Press.

[48] Grant, N.G. (1969): Human facial expression. *Man*, 4:525.

[49] See Ekman (1982): *op. cit.*, for a critical review of fourteen techniques for measuring facial behavior.

[50] Ekman, P., Friesen, W.V., and Tompkins, S.S. (1971): Facial affect scoring technique: a first validity study. *Semiotica*, 3:37.

[51] Seaford, H.W. (1976): Maximizing replicability in describing facial behavior. Paper presented at the Annual Meeting of the Americal Anthropological Association, Washington, DC.

[52] Washburn, S.L. (1975): Personal communication.

[53] Duchenne: *op. cit.*, p. 23, this volume.

Friesen and I borrowed extensively from Duchenne, and from a contemporary anatomist, Hjorstjo,[54] who did not cite Duchenne but whose work embraced Duchenne's discoveries by specifying the muscles that produce specific changes in facial appearance. Using both Duchenne's data and his method, I tested the activity of a number of muscles of whose action I was uncertain. I was my own subject, putting needles into my face either to stimulate electrically a particular muscle or to record electrical changes when I voluntarily contracted a muscle.

The needle was not pleasant, and Friesen and I mostly used our voluntary performance of specific muscle movements to film the changes produced by different combinations of muscle actions. Our contribution, building on Duchenne, was to explore many more combinations of muscle movements than he or anyone else had considered. We performed, photographed, and analyzed nearly 10,000 combinations of facial muscle movements. Using the information about how these actions changed appearance, we constructed a measurement technique that allowed the user to decompose any observed facial movement into the muscular actions that produced it. Our Facial Action Coding System – FACS[55,56] – is now being used by several hundred scientists.

Unknown to us when we were developing FACS, Ermiane and Gergerian[57] were developing a very similar technique to measure facial movement comprehensively in anatomical terms. They too built upon Duchenne and acknowledged his important role. Soon afterward, Izard published a third anatomically based measurement system.[58] It is similar to FACS, but only attempts to measure those facial movements Izard thought were related to emotion.

The last approach to measuring facial behavior has been to record electrical activity in different facial regions with electromyography (EMG). This technique promises to monitor emotional activity when there is no visible facial movement.[59] It too depends upon the knowledge provided

[54] Hjorstjo, C.H. (1970): Man's face and mimic language. Lund: Student-Literature.
[55] Ekman and Friesen (1976): *op. cit.*
[56] Ekman and Friesen (1978): *op. cit.*
[57] Ermiane, R. (1949): *Jeux musculaires et expressions du visage.* Paris: Libraire le François. Ermiane, R. (1970): *Visages et caractères,* 6th edition, mimeographed. *Atlas of facial expresions (Album des expressions du visage)* by Roger Ermiane (1976), translated by Edmund Gergerian. Paris: La Pensée Universelle.
[58] Izard (1979): *op. cit.*
[59] Cacioppo, J.T., Martzke, J.S., Petty, R.E., and Tassinary, L.G. (1988): Specific forms of facial EMG response index emotions during an interview: From Darwin to the continuous flow hypothesis of affect laden information processing. *Journal of Personality and Social Psychology,* 54:592.

by Duchenne, and those who followed him, about the muscles that produce specific changes in facial activity.

The current flurry of research measuring facial behavior – whether visible facial expression or EMG measurement of facial activity – rests upon the mechanics of facial movement pioneered by Duchenne. In almost all respects Duchenne's findings have been validated. The one disagreement regards the activity of *m. corrugator supercilii,* to which Duchenne attributed the raising of the inner corners of the eyebrow. Friesen and I[60] claimed instead that *m. corrugator supercilii* draws the brows down and together. We attributed the drawing-up of the inner corners of the eyebrows to the inner portion of *m. frontalis,* which may sometimes be joined by *m. corrugator supercilii.* Duchenne failed to note that the inner and outer portion of *m. frontalis* can act independently. Darwin and Hjorstjo agreed with our, not Duchenne's, explanation of how these muscles function.

I want to remind the reader who has survived this discussion of methodology that Duchenne was a marvelously gifted observer. Quite apart from the importance of his discoveries on how the facial muscles work, he contributed a variety of fascinating ideas about emotion and expression, many of which I have described in the first part of this chapter. Duchenne often asked questions that still are unresolved by those who study emotion today.

Seemingly perplexed by the large list of emotions described by such writers as Plato, Aristotle, Cicero, Descartes, and Hobbes, Duchenne commented:

> Perhaps it isn't given to man to express all his emotions on his face, especially when we consider the many different emotions that have been named and arbitrarily classifed by the philosophers.[61]

It does appear that there are more words describing emotions than distinctive facial expressions, although some of these variations may be due to differences in intensity of the same, or the blending of more than one, emotion. I have argued[62] that a pancultural facial expression is *one* of the distinguishing characteristics of an emotion, and that phenomena that do not have a distinctive, universal expression should not be considered emotions, but instead may be moods, attitudes, or preferences.

[60] Ekman and Friesen (1978): *op. cit.*

[61] Duchenne: *op. cit.*, p. 28, this volume.

[62] Ekman, P. (1984): Expression and the nature of emotion. In *Approaches to emotion,* (Sherer, K., and Ekman, P., Eds.). Hillsdale, New Jersey: Lawrence Erlbaum, p. 319.

Duchenne, a few sentences later, points to what I still believe may provide us with an answer to the question of "what are the emotions?"

> One day, perhaps, these electrophysiological studies on the different modes of expression of human "physionomie" will serve as the foundation for a better classification of the emotions founded on the observation of nature.[63]

[63] Duchenne: *op. cit.*, p. 29, this volume.