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The Duchenne Smile: Emotional Expression and Brain Physiology II

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Facial expression, EEG, and self-report of subjective emotional experience were recorded while subjects individually watched both pleasant and unpleasant films. Smiling in which the muscle that orbits the eye is active in addition to the muscle that pulls the lip corners up (the Duchenne smile) was compared with other smiling in which the muscle orbiting the eye was not active. As predicted, the Duchenne smile was related to enjoyment in terms of occurring more often during the pleasant than the unpleasant films, in measures of cerebral asymmetry, and in relation to subjective reports of positive emotions, and other smiling was not.

In the introduction to his book *The Expression of the Emotions in Man and Animals* (1872/1955), Darwin described his indebtedness to the French anatomist Duchenne de Boulogne, who had published his *Mecanisme de la Physionomie Humaine* 10 years earlier, in 1862. Darwin explained how Duchenne

> analyses by means of electricity, and illustrates by magnificent photographs, the movements of the facial muscles. . . . No one has more carefully studied the contraction of each separate muscle, and the consequent furrows produced on the skin. He has also, and this is a very important service, shown which muscles are least under the control of the will. (1872/1955, p. 5)

Observing differences in the appearance of spontaneous smiling (Figure 1) and a smile resulting from electrical stimulation of the zygomatic major muscle (Figure 2), Duchenne wrote:

> The emotion of frank joy is expressed on the face by the combined contraction of the zygomaticus major muscle and the orbicularis oculi. The first obeys the will but the second is only put in play by the sweet emotions of the soul; the. . . fake joy, the deceitful laugh, cannot provoke the contraction of this latter muscle.. . . The muscle around the eye does not obey the will; it is only brought into play by a true feeling, by an agreeable emotion. Its inertia, in smiling, unmasks a false friend. (1862/in press)[1]

Ekman (1989) has suggested that this form of smiling—distinguished by the combination of both the zygomatic and orbicularis oculi muscles—which is hypothesized to occur with spontaneously occurring enjoyment, be called the *Duchenne smile.*

Until very recently, scientists studying facial expression ignored Duchenne's advice about how to distinguish voluntary, false, or deceitful smiling from involuntary smiles of enjoyment. This failure to distinguish among smiles may account for much of the confusion over the last 60 years about what smiles signify and when they occur.

The appearance of smiling in unpleasant circumstances was often cited by cultural anthropologists as proof that facial expressions of emotion are not universal but specific to each culture. LaBarre quoted a description of Africans: ". . . laughter is used by the Negro to express surprise, wonder, embarrassment and even discomforture; it is not necessarily or even often a sign of amusement" (Gorer, 1935, cited in LaBarre, 1947, p. 52). LaBarre commented, "Thus it is that even if the physiological behavior be present, its [the smile or laugh] cultural and emotional functions may differ" (LaBarre, 1947, p. 52). Birdwhistell described how, early in his research, he was preoccupied ". . . with human universals, [and] I attempted to study the human smile. . . . Not only did I find that a number of my subjects 'smiled' when they were subjected to what seemed to be a positive environment but some 'smiled' in an aversive one. . . ." (1970, pp. 29–30). "This search for universals was culture bound. . . . There are probably no universal symbols of emotional state. . . . We can expect them [emotional expressions] to be learned and patterned according to the particular structures of particular societies" (Birdwhistell, 1963, p. 126).

Within experimental psychology, the conclusion that facial expressions do not provide much accurate information about emotion—the position taken in Hunt's (1941), Bruner and Tagiuri's (1954), and Tagiuri's (1968) influential literature reviews—was buttressed by observations that subjects often smile in unpleasant circumstances. Landis's (1924) classic experiment on spontaneous facial expression was given considerable weight by these reviewers. Landis had photographed his stu-

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[1] Duchenne's book has been out of print for decades. Our quote is from the first English translation (Duchenne, in press), which should appear next year.

dents when they listened to music, looked at pornographic pictures, smelled ammonia, were shocked, observed him decapitate a live rat, and so forth. Observers who then looked at these photographs were unable to determine accurately the situations in which the expressions occurred. In particular, Landis made much of his finding that smiles were frequent in all of his situations, thus showing that the smile is a meaningless expression.

More recently, Ekman, Friesen, and O'Sullivan (1988) suggested that the failure to distinguish among smiles may account for contradictory findings in studies of interpersonal deception. They reviewed 12 studies conducted over the last 10 years that found that subjects smiled equally often when they were telling the truth or telling a lie. As reported below, that did not happen in their study, in which the Duchenne smile was distinguished from other smiles.

In all of this work—anthropological observations and experimental studies of emotion and of deception—smiles were treated as a single class of behavior. No distinctions were made among types of smiles. Little recognition was given to the obvious fact that smiles, like many other facial expressions, can be performed voluntarily or may appear involuntarily. No one took note of Duchenne's more specific hypothesis about how to distinguish a smile of enjoyment, which typically occurs involuntarily, from other types of smiling. (An exception are the few ethologists [Blurton Jones, 1972; Brannigan & Humphries, 1972; Grant, 1969] who did distinguish among types of smiling, but they did not separate the Duchenne smile from other smiling activity.)

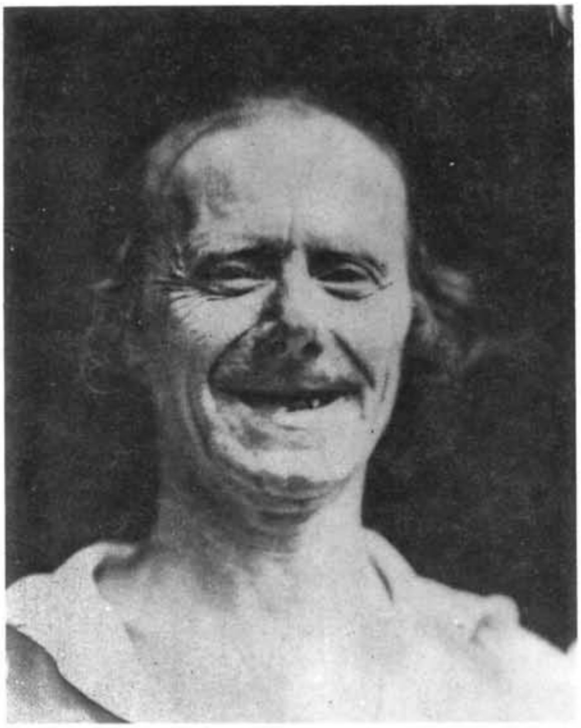

Figure 1. Spontaneous smile of enjoyment according to Duchenne (1862/in press). (Compare the cheeks and the skin gathered in around the eyes in this figure with Figure 2.)

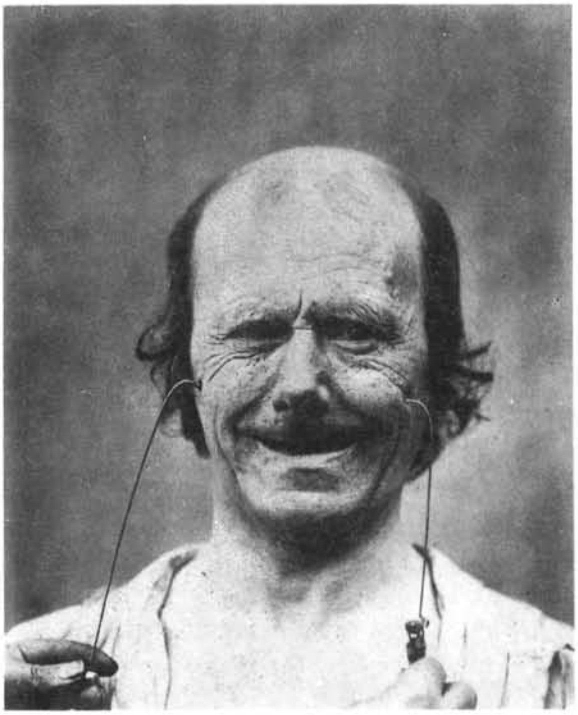

Figure 2. The zygomatic major muscle stimulated to produce a smile (Duchenne, 1862/in press).

Ekman and Friesen (1982) expanded on Duchenne's observations in proposing how to distinguish *enjoyment smiles*[2] from a number of other types of smiling. Enjoyment smiles, they said, can be distinguished from other smiles not only on the basis of the muscles that produce the smile (i.e., the Duchenne smile), but also on the basis of the timing of the smile and the coincidence of the smile with speech and other motor behavior. Recognizing that enjoyment may come about in many ways, including earning praise, accomplishment, relief, amusement, or pleasure from visual, auditory, gustatory, kinesthetic, or tactile sources, Ekman and Friesen nevertheless claimed that smiles in all these enjoyable circumstances would be distinguishable from other types of smiling in which there is no enjoyment.

Ekman and Friesen described the appearance of "false smiles," which are made deliberately to convince another that enjoyment is occurring when it is not; "masking smiles," which are made deliberately to conceal the experience of negative emotions; and "miserable smiles," which acknowledge a willingness to endure an unpleasant circumstance. Ekman (1985) also described 14 other types of smiles.

In their first test of this formulation, Ekman et al. (1988) examined the incidence of the Duchenne smile and masking

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[2] They originally called these "felt smiles," but because that phrase could imply that the crucial issue is whether the person actually is aware of the smile itself, Ekman (1989) proposed that this class of behavior be called instead "enjoyment smiles."

smiles when people were truthfully describing positive emotions and when they feigned enjoyment to conceal strong negative feelings. As predicted, the Duchenne smile occurred more often when people were actually enjoying themselves, whereas masking smiles occurred more often when people were feigning enjoyment but experiencing negative emotions.

A number of other investigators, using Ekman and Friesen's distinctions among smiles, have found evidence suggesting that the Duchenne smile is a sign of enjoyment. Matsumoto (1986) found that depressed patients showed more Duchenne smiling in a discharge interview as compared to an admission interview, with no difference in the amount of other smiling. Steiner (1986) found that Duchenne smiling, but not other types of smiles, increased over the course of psychotherapy in patients who were judged to have improved. Krause, Steimer, Sanger-Alt, and Wagner (1989) found that during interviews schizophrenics showed fewer Duchenne smiles than normal individuals, but there was no difference between the groups in other smiling. Ruch (1987) found that Duchenne smiles were sensitive to the amount of humor felt by adults when responding to jokes.

In all of these studies the subjects were engaged in face-to-face communication. It could be argued that perhaps only when people are so focused on communicating that a difference would be found between the Duchenne and other types of smiling. Our experiment addressed this matter by studying subjects who were not trying deliberately to communicate. They experienced emotions while they sat alone, with no one present, watching a series of short motion picture films. Because it was important to reduce the possibility that subjects might imagine that another person was observing them if they knew we were recording their expressions, they were not told about the videotape recording until after the experiment was over. The camera was hidden and not discovered by any of the subjects. They believed our sole interest was in the physiological recordings that were made while they watched the films.

Some investigators (Andrew, 1963; Kraut, 1978; Smith, 1985) have taken the position that facial expressions should not be conceptualized in terms of emotions, but *only* as social interactive signals. In a solitary, private situation they expect that facial expressions will not occur or, if they do, they will not be related to subjective emotional experience or physiological changes. We believe that this view that facial expressions occur only during social interaction is incorrect. Granting that emotions are often brought forth by interactive events, Ekman and Friesen (1969, 1975; Ekman, 1977, 1989) maintain that emotions are elicited also by nonsocial events (e.g., fear aroused by a loss of support, a variety of emotions aroused by entertainment media, and positive emotions aroused by seeing a beautiful sunset). Although the social context often occasions and amplifies an expression of emotion, it may also dampen or inhibit an emotional expression. Ekman and Friesen (1969) coined the phrase "display rules" to describe such attempts to manage facial expression, in terms of who can show what emotion to whom and when. (See Malatesta and Kalnok, 1984, for recent evidence on display rules.)

Emotional experience and expression would not, from our vantage point, be absent when an individual is alone. When experiencing positive or negative emotions, a variety of smiles may occur, but the Duchenne smile, we predict, will occur during solitary enjoyment. We have compared these smiles with a variety of "other smiles." When watching positive films, two other kinds of smiles may occur: anticipatory smiles, when someone anticipates the likelihood of soon experiencing enjoyment; and positive–negative blends, when the film evokes a memory that blends enjoyment with some negative emotion. When watching the negative films, there should be few Duchenne smiles, although they might not be totally absent. They may appear, for example, if a subject becomes amused about suffering the impact of the negative films. Miserable smiles, in which the subject acknowledges being in a miserable situation, and masking smiles may also occur. Finally, anticipatory smiles may occur if the subject is anticipating the relief that may be experienced when the film ends.

Our experiment differed from prior studies of smiling, not only in examining people who were experiencing emotion when alone, but in other ways as well. It is the first study to determine how different forms of smiling relate to the subjective experience of emotion. It is also the first to determine whether the Duchenne smile could not only distinguish positive from negative emotions, but which of two positive experiences was most enjoyable. Finally, it is the first to examine the relationship between types of smiling and cerebral hemisphere activity in adults. Fox and Davidson (1988) examined this relationship in infants and found that Duchenne smiling was associated with more left-sided frontal activation compared with other smiles, whereas other smiles were associated with right-sided frontal activation compared with Duchenne smiling.

A growing literature that has established differences between the two hemispheres of the brain in their involvement in certain positive and negative emotions suggests that there would be different physiological activity associated with the Duchenne smile as compared to other kinds of smiling (see Davidson, 1984, 1987; Silberman & Weingartner, 1986; and Tucker & Frederick, 1989, for reviews). The evidence on hemispheric activity and emotion comes from a diversity of sources, including studies of the emotional consequences of unilateral brain damage (e.g., Robinson, Kubos, Starr, Rao, & Price, 1984), of unilateral injections of sodium amytal in patients prior to neurosurgery (e.g., Lee, Loring, Meador, & Flanigin, 1988; Rossi & Rosadini, 1967), and of asymmetries in regional brain activation in normals using measures based on both brain electrical activity and regional cerebral blood flow (e.g., Davidson, 1984, 1987).

The asymmetries associated with the production of emotion have been most consistently observed in the frontal and anterior temporal regions. Subjects show relative left-sided activation during certain positive emotions compared with negative emotions and more relative right-sided activation during certain negative emotions compared with positive emotions. It is important to note that the findings are always described as relative differences between two or more conditions. Predictions in terms of absolute asymmetry are not offered, at least with small sample sizes, because there are large and stable individual differences in absolute asymmetry, upon which phasic effects are superimposed. Thus, in a subject with extreme right frontal activation, happiness may not produce absolute left frontal activation. Rather, compared with disgust, one would expect more left frontal activation during happiness.

In our experiment, subjects watched positive and negative emotional film clips while they were unobtrusively videotaped. In addition, brain electrical activity was measured. We tested the following specific hypotheses:

Hypothesis 1: There will be more Duchenne smiling when subjects watch positive films than when they watch negative films, whereas other smiles will not distinguish whether subjects watch positive or negative films.

Hypothesis 2: The Duchenne smile but not other smiling will correlate with the subjective experience of positive emotions.

Hypothesis 3: The Duchenne smile but not other smiles will predict during which of two positive emotion films a subject reported feeling most amused and most happy.

Hypothesis 4a: The Duchenne smile will be accompanied by greater left anterior (i.e., frontal and anterior temporal regions) activation compared with other smiles, whereas other smiles will be associated with more right-sided anterior activation compared with the Duchenne smiles. Our prediction regarding other smiles is based on three facts. First, we previously found that in infants, other smiles were associated with more right-sided frontal activation compared with Duchenne smiles (Fox & Davidson, 1988). Second, the situation that elicited predominantly other smiles in the infant study (i.e., stranger approach) also produced behavioral signs of withdrawal (gaze aversions), which Davidson (1984) has argued should be accompanied by relative right-sided anterior activation. Finally, the facial behavior that accompanies the production of other smiles often includes action units that are present during negative affect. As will be noted below, this also occurred in the present study.

Hypothesis 4b: When compared with baseline, Duchenne smiling will be associated with relative left-sided anterior activation, whereas other smiling will be associated with relative right-sided anterior activation.

Method

Subjects

A total of 37 right-handed (assessed with the Edinburgh Handedness Inventory; Oldfield, 1971) women between the ages of 17 and 41 years were tested. The sample was restricted to right-handed subjects because asymmetry measures were being obtained. Of these 37 subjects, 34 completed all of the ratings of subjective experience of emotion, and 31 had some usable electroencephalogram (EEG) data during at least one of the conditions.

Procedure

Subjects were tested individually. Prior to the experiment they were told that their subjective and physiological reactions to films designed to elicit both positive and negative emotions would be studied. The experiment began with baseline recordings of physiology, after which the film clips were presented. Following the presentation of the film clips, another set of baseline trials was presented.

Emotion-Arousing Stimuli

There were five film trials, each comprising a different short film of approximately 90 s in duration. The first film clip was used to acclimate subjects to the procedure. The next two were intended to evoke positive emotions, and the last two were designed to evoke negative emotions. Prior research with these films (Ekman & Friesen, 1974; Ekman, Friesen, & Ancoli, 1980) had found that subjects reported strong feelings of happiness and showed smiling expressions during the positive films. Feelings of fear, sadness, disgust, and pain and a variety of negative emotional expressions occurred in response to the negative films.

All the films were silent and in color. One of the positive films showed a puppy playing with flowers. The second showed monkeys playing and gorillas taking a bath in the zoo. The order in which the puppy versus primate film clip was presented was counterbalanced across subjects.

The two negative films clips always followed the positive clips. The rationale for this was based on previous work by Ekman et al. (1980, 1988) and by our own pilot work, which indicated that the negative affect elicited by the negative films tended to persist longer than the positive affect elicited by the positive films. If we had counterbalanced the order of positive and negative films, the persisting negative affect would have interfered with the intended effect of the positive films. The negative film clips were taken from training movies used in the teaching of nurses. One clip depicted a leg amputation and the other was the scene of a third-degree burn victim. Both were quite gruesome.

Subjective Ratings of Emotion

After each of the baseline and film trials, subjects rated the emotions they had felt during the preceding trial on a series of unipolar scales. Separate scales were included for interest, happiness, amusement, contentment, excitement, fear, sadness, anger, disgust, pain, and arousal. The instructions told the subject that zero represented no emotion and 8 the most intense feeling of that emotion. These rating scales were projected one at a time on the rear projection screen. The subjects entered their rating by pressing a number on their key pad.

Video Recordings

During each of the film clips, subjects were videotaped unobtrusively through a wire mesh screen that served as the border of the rear projection screen. The camera was absolutely invisible to the subject, and not one subject suspected that she was being videotaped. After the experiment was completed, subjects were thoroughly debriefed, and written consent was requested to use their videotapes for scientific purposes. The subject was told that if she did not wish for the tape to be used, it would be erased. No subject declined our request to use her tape.

EEG Recording Procedure

The EEG was recorded from the left and right frontal, central, anterior temporal, and parietal regions (F3, F4, C3, C4, T3, T4, P3, P4) all referred to vertex (Cz) using a lycra stretchable cap (Electro-Cap). For more information about these recordings, as well as more details about the procedure, emotion-arousing stimuli, and video recordings, see the accompanying article (Davidson, Ekman, Saron, Senulis, & Friesen, 1990). That article also describes in the introduction eight methodological desiderata for psychophysiological research on emotion that are relevant to this study as well.

Data Analysis

Scoring facial behavior. All of the observable facial activity shown by each subject during the positive and negative films was measured with Ekman and Friesen's (1976, 1978) Facial Action Coding System (FACS). FACS distinguishes 44 *action units.* These are the minimal units that are anatomically separate and visually distinctive. Any facial movement can be described in terms of the particular action unit that, singly or in combination with other units, produced it. The scorer identifies the action units, such as the one that pulls the lip corners up or that lowers the brow, rather than making inferences about underlying emotional states such as happiness or anger, or using descriptions that mix inference and description such as smile, scowl, or frown. In addition to specifying which action units produced each observed expression, the beginning and end of each expression was determined.

Intercoder reliability has been established for this scoring procedure in a number of laboratories (cf. Ekman & Friesen, 1976; Ekman et al., 1980; Ekman, Friesen, & Simons, 1985; Ekman et al., 1988; Fox & Davidson, 1988; Krause et al., 1989; Ruch, 1987; Steiner, 1986). In our study two coders who did not know the hypotheses each scored about half of the videotapes. Each of these coders had more than 1 year's experience using FACS, and their reliability had been established both against a standard criterion (Ekman and Friesen's own scoring) and against each other.

FACS scoring can provide either frequency or duration data on each facial action. The duration of facial actions is probably a more accurate index of emotion because duration is sensitive to very long expressions, which may be given little weight if only frequency is considered. However, frequency is less costly to obtain because the precise onset and offset of each action is not required as it is to determine duration, and therefore most investigators have reported frequency data. In this experiment the onset and offset of each facial action had to be determined to coordinate the facial actions with the EEG record. All of the results were computed separately with frequency and duration scores. There were no differences in the significance levels obtained. We report only the duration data because we believe they represent the more accurate scores.

Although the FACS scoring revealed that many different facial actions occurred apart from smiling behaviors, our hypotheses focused only on two groups of smiles. The Duchenne smile (D-smile) was composed of all instances in which the smile was produced by the zygomatic major muscle and the lifting of the cheeks and gathering of the skin around the eye were produced by the orbicularis oculi muscle. We deviated from Duchenne in excluding smiles in which the activity around the eyes was due to the inner strands of the orbicularis oculi muscle (pars palpebralis), not the outer strands (pars lateralis). We made this decision on the basis of Ekman, Roper, and Hager's (1980) finding that fewer people can voluntarily contract the outer as compared to the inner strands of this muscle. This suggested that there would be greater certainty that the expression was involuntary if only instances in which the outer portion of the orbicularis oculi muscle were included in the category of D-smiles.

Other smiles (O-smiles) were composed of all other instances in which the smile was produced by the zygomatic major muscle but the orbicularis oculi, pars lateralis was absent. These included instances in which the smile was produced by only the zygomatic major muscle, as well as expressions in which this muscle was joined by a variety of other facial muscles, including facial actions associated with negative emotions. For each subject the total duration during which either type of smile occurred was computed for each of the two positive and two negative films.

Artifact editing of EEG. All EEG records were visually scored for artifact. All eye movement and muscle artifacts were removed from the data prior to analysis. If artifact was present on any channel, data from *all* channels were removed so that the EEG data were always taken from coincident points in time.

EEG analysis. The main EEG data in this experiment were derived from the positive film clips during those periods when the Duchenne smile and other smiles were present *and* no artifact was present. The onset and offset times of these facial expressions were entered into the computer along with the times during which artifact was not present. The computer then extracted those portions of the EEG record that were 1.02 s or longer in duration for analysis that corresponded to the overlap of these two criteria. We chose to extract the EEG during each of these two smile types in response to the positive film clips only, because the D-smiles occurred with far more frequency during the positive compared with the negative clips. If we were to have used all instances of D-smiles and O-smiles, the comparison would have confounded different smile types with different film clips in response to which they were elicited.

For analyses of the baseline periods, we used only the eyes-open trials because they were considered to be the most appropriate comparisons for the film conditions during which subjects' eyes were also open. All artifact-free periods of EEG from the pre- and postfilm baseline trials that were 2.05 s or more in duration were used in the analysis. Chunks of EEG (1.02-s periods for the facial expressions and 2.05-s periods for the baseline) were extracted using a Hamming window and were overlapped by 75%. A Fast Fourier Transform was applied to each chunk of EEG. Power values from successive chunks within a condition (i.e., smile type or baseline) were averaged. The dependent measures that were extracted from this analysis were power density (in $\mu V^2/Hz$) in the alpha (8–13 Hz) and beta (13–20 Hz) bands. Power in the alpha band is inversely related to activation, so that lower values denote more activation (Lindsley & Wicke, 1974). Beta power was also examined. However, on the basis of our previous data and comparisons among bands in EEG asymmetry in response to carefully matched tasks, we hypothesized that the major effects would occur in the alpha band (see the accompanying report for additional details on the EEG analysis methods; Davidson, Chapman, Chapman, & Henriques, in press).

Results

Did the Type of Smile Vary With the Experimental Condition?

Hypothesis 1 predicted that there would be more D-smiles when subjects watch positive films than when they watch negative films, whereas O-smiles would not distinguish whether subjects were watching positive or negative films. To test this hypothesis, four summary scores were computed for each subject: the duration of D-smiles and O-smiles summed over the two positive films and summed over the two negative films. These four scores were entered into a 2 × 2 Film Type (positive–negative) × Smile Type (D-smile–O-smile) repeated measures analysis of variance (ANOVA).

A significant main effect for film type, $F(1, 36) = 40.22, p < .001$, indicated that there were differences in the amount of overall smiling between the positive and negative films. The main effect for smile type was not significant, $F(1, 36) = .51$, $p < .48$, indicating that when type of film was not considered there was no difference in the amount of D-smiles as compared to O-smiles. The significant interaction between film type and smile type, $F(1, 36) = 5.08, p < .03$, showed that different types of smiling occurred in the positive and negative films. As predicted by Hypothesis 1, there were more D-smiles during the positive films than during the negative films ($t = 2.48, p = .005$, one-tailed test); O-smiling during the positive and negative films did not differ ($t = 1.06, p = .15$, two-tailed test). Figure 3 shows the mean duration for each type of smile during the positive and negative films. The figure also shows that the ratio of D-smiles during the positive as compared to the negative films

Figure 3. Mean duration (in seconds) of each type of Duchenne's smile and other smiles in response to the positive and negative film clips.

was 10:1, and the ratio of O-smiles during positive as compared to negative films was 2:45 to 1.

Did the Type of Smile Relate to the Subjective Experience of Emotion?

Hypothesis 2 predicted that D-smiles but not O-smiling would be correlated with the subjective experience of positive emotions. Whereas researchers studying the self-report of mood (Clark & Watson, 1988; Diener & Emmons, 1984; Stone, 1981) have argued against distinguishing among types of positive *moods,* we (Ekman, 1977; Ekman & Friesen, 1975) have argued for making such distinctions among *emotions.* We agree with Tomkins (1962) that interest and excitement refer to a different state than happiness or enjoyment. As Woodworth (1938, p. 411) said, "The fact is that there are many kinds of pleasant feeling, and of unpleasant. Some of the words do not indicate whether the feeling is pleasant or unpleasant; excitement may be happy excitement or unhappy excitement, and this is true of expectancy and surprise."

Although the D-smile may occur with interest and excitement, it will only do so in circumstances in which those emotions blend with or occur in sequence with amusement or happiness. In our experiment interest and excitement, if felt, would occur interspersed with amusement and happiness. Thus, if D-smiles are correlated with reports of interest and excitement, it would be due to the association of those feelings with amusement and happiness.

We consider happiness and enjoyment as general terms that cover a variety of different positive emotional experiences such as sensory pleasure, relief, satisfaction with accomplishment, amusement, and contentment. Although we expect that each of these positive emotions is experienced differently, with different sensations and physiology, we (Ekman & Friesen, 1982) have hypothesized that all of these positive states share the same expressive signal—the Duchenne smile.

Because the positive films shown to the subjects were designed to be amusing, we predicted that D-smiles but not O-smiles would be correlated with reports of either the more specific term *amusement* or the more general report of happiness. We did not expect a substantial correlation between D-smiles and contentment because these films were not likely to elicit much contentment.

Table 1 reports the correlations between the duration of Duchenne and other smiling with each of the emotion self-reports. Hypothesis 2 was supported. Only D-smiles, as predicted, were correlated with reports of amusement and happiness. D-smiles were also positively correlated with excitement and interest, although these relationships were not as strong as the correlations between D-smiles and amusement or happiness. The correlation between D-smiles and amusement was significantly greater than the correlation between D-smiles and either excitement ($t = 2.49, p < .01$) or interest ($t = 2.22, p < .05$, one-tailed tests). The correlation between D-smiles and happy was significantly greater than the correlation between D-smiles and excitement ($t = 1.69, p < .05$).

Partial correlations showed that the relationships between D-smiles and either interest or excitement were, as we predicted, enormously reduced when the variance associated with amusement was removed. Table 2 shows that when the self-reports of happiness or amusement were partialled out, the correlations between D-smiles and either interest or excitement disappeared. The converse was not so; when the influence of either interest or excitement was partialled out, the correlations between D-smiles and either amusement or happiness survived.

Because amusement and happiness ratings were highly correlated (.791), we computed partial correlations with D-smiles and these two ratings. Table 2 shows that when the influence of happiness ratings was controlled, the partial correlation between D-smiles and amusement was still substantial. However, when the influence of amusement ratings was controlled, the partial correlation between D-smiles and happiness was enormously reduced.

Table 1 shows two other findings that were not predicted by Hypothesis 2. D-smiles were negatively correlated with reports of feeling anger and sadness, and O-smiles were positively correlated with the report of disgust.

Hypothesis 3 predicted that D-smiles but not O-smiles would predict during which of the two positive films a subject had reported feeling most amused and most happy. This is a difficult discrimination because both the puppy and the primate films had evoked ratings that were at or very close to the median on

Table 1
Correlations Between Type of Smile and Self-Reported Emotions (N = 34)

Type	Amusement	Happy	Excitement	Interest	Contentment	Anger	Disgust	Fear	Pain	Sad
Duchenne smile	.703*	.594*	.387***	.401***	.199	−.381***	−.322	−.299	−.218	−.439**
Other smiles	.135	.180	.080	.189	.104	.283	.340**	.079	.259	.263

* $p < .001$, one-tailed test. ** $p < .01$, two-tailed test. *** $p < .05$, two-tailed test.

amusement and on happiness. In this idiographic analysis, a subject was considered correctly classified if the duration of smiling shown during the two films coincided with the positive emotion ratings on the two films. Thus, a "hit" could occur in one of three ways: The puppy film was rated more positively than the primate film and there was more smiling during the puppy film than during the primate film; the two films were rated the same and there was no difference in the amount of smiling; or the ratings on the puppy film were less positive than for the primate film and there was less smiling during the puppy film. The six possibilities in which the ratings and amount of smiling disagreed were considered to be "misses."

One-way chi-square analyses were computed using the amusement and happiness ratings on the two films. The expected hit rate was set at .33 because there was a total of nine combinations of ratings and smiles, three of which were hits and six of which were misses. Table 3 shows that predictions of which film was most amusing or evoked most happiness was accurate when made on the basis of the amount of D-smiles but not on the basis of O-smiles. Two by two chi-square analyses were also computed on the hit–miss rate by type of smiling. The difference in the hit rate between D-smiles and O-smiles was significant for the happiness ratings ($\chi^2 = 3.31$, $p < .05$, one-tailed) and marginal for the amusement ratings ($\chi^2 = 2.13$, $p = .08$, one-tailed test).

Were the Types of Smile Associated With Differences in Brain Asymmetry?

The EEG during D-smiles and O-smiles was extracted from the two positive films. We included in this analysis only those subjects who had both D-smile and O-smile periods so that the design could be completely within subjects. A total of 13 subjects had at least one instance of D-smiling and O-smiling within the positive film clips that coincided with artifact-free EEG. Of these 13 subjects, 7 had facial signs of negative affect present during other smiles. The mean durations of D-smile and O-smile periods that were extracted for analysis were 20.9 and 21.6 s, respectively.

Our strategy for analysis was to first compare the D-smiles, O-smiles, and baseline conditions by computing separate 3 × 2 ANOVAs with condition (D-smile–O-smile–baseline) and hemisphere (left–right) as repeated factors on EEG power from each of the four regions. These overall analyses used the Huynh–Feldt correction to correct for departures from homogeneity of variance given a repeated factor with more than two levels. Two-way ANOVAs on each pair of conditions were then computed to decompose the interaction. The major findings were derived from analyses of alpha power, as we had predicted. After presenting the data on alpha power, we also present the results of analyses on beta power.

Alpha Power

Anterior regions. The ANOVA on the frontal data revealed a significant Condition (D-smile–O-smile–baseline) × Hemisphere interaction, $F(2, 24) = 3.31$, $p = .054$, with Huynh–Feldt correction, and no significant main effects. This interaction was decomposed by performing separate Condition × Hemisphere ANOVAs for each pairwise condition combination. The Condition × Hemisphere interaction for the comparison between D-smiles and O-smiles was not significant, $F(1, 12) = 2.06$, failing to support Hypothesis 4a for the frontal data. In comparing D-smiles with baseline, the Condition × Hemisphere interaction was also not significant, $F(1, 12) = 1.55$. However, the Condition × Hemisphere interaction was significant for the O-smile versus baseline comparison, $F(1, 12) = 5.53$, $p = .04$, supporting one component of Hypothesis 4b (Figure 4). This interaction is a function of a significant decrease in right frontal alpha power (i.e., more activation) during O-smiles compared with baseline ($p < .01$). Left-hemisphere alpha power did not differ significantly between baseline and the O-smiles. During O-smiles, absolute right frontal activation was found, with signifi-

Table 2
Partial Correlations Between D-Smiles and Self-Reported Emotions

Partialing on	D-smile and excitement	D-smile and interest	D-smile and amusement	D-smile and happiness
Amusement	−.013	−.077		.089
Happiness	−.026	.189	.474	
Excitement			.637	.489
Interest			.633	.506

Table 3
Discrimination Between Which of the Two Positive Films Was Rated as Most Happy or Most Amusing on the Basis of D-Smiles and O-Smiles

	% of hits	Chi-square	*p*
Happiness ratings			
Duchenne smiles	73	25.25	.0001
Other smiles	41	1.027	*ns*
Amusement ratings			
Duchenne smiles	65	15.45	.0001
Other smiles	44	1.899	*ns*

cantly less right-hemisphere compared with left-hemisphere alpha power ($p < .01$).

The overall ANOVA on the anterior temporal EEG revealed a Condition (D-smile–O-smile–baseline) × Hemisphere interaction that fell just short of significance, $F(2, 24) = 3.23, p < .06$, with Huynh–Feldt correction. As we observed for the other brain regions, no significant main effects were obtained. The Condition × Hemisphere interaction for the direct comparison of the D-smile and O-smile periods also fell short of significance, $F(1, 12) = 3.79, p < .08$. Because this interaction was predicted by Hypothesis 4a, we computed the simple effects. As Figure 5 indicates, D-smiles were associated with significantly more left anterior activation (i.e., less alpha power) compared with O-smiles ($p < .05$). No difference between smile types was found in the right anterior temporal region. Alpha power in the left and right anterior regions did not differ during D-smiles. However, during O-smiles, we found significantly more ($p < .05$) right compared with left anterior temporal activation (i.e., less alpha power).

When each expression type was compared with baseline, we found the same pattern as was described for the other brain regions—a significant Condition × Hemisphere interaction only for the comparison between baseline and O-smiles, $F(1, 12) = 4.84, p < .05$. Again, no main effects were obtained in this analysis. Compared with baseline, O-smiles were associated with less alpha power (i.e., greater activation) in the right anterior temporal region ($p < .01$). No significant difference in left anterior temporal alpha power was found between baseline and O-smiles.

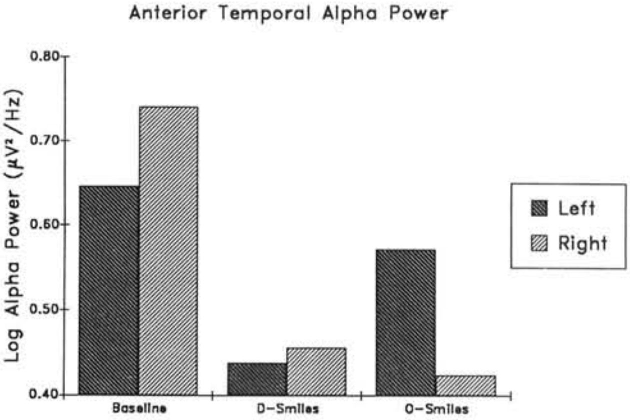

Figure 5. Mean alpha power in the left and right anterior temporal regions (T3 and T4, respectively) for the baseline condition and during Duchenne's smiles and other smiles.

Parietal and central regions. We did not have any specific a priori hypotheses concerning the parietal data. In previous studies, we have found more consistent asymmetry differences between emotion conditions that differ on valence in the anterior regions than in the parietal region, although in one study we did find parietal asymmetry to differentiate between positive and negative emotion conditions in the same direction as frontal asymmetry (Fox & Davidson, 1986).

The overall Condition (D-smile–O-smile–baseline) × Hemisphere interaction on the parietal data was significant, $F(2, 24) = 3.46, p < .05$, with Huynh–Feldt correction. No significant main effects were obtained (see Figure 6). When we de-

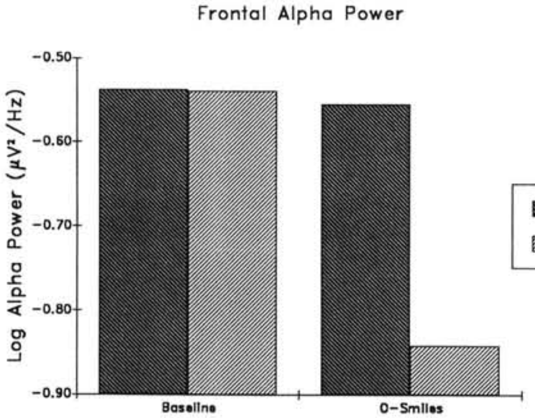

Figure 4. Mean alpha power (in $\mu V^2/Hz$) in the left and right mid-frontal regions (F3 and F4, respectively) for the baseline condition and during other smiles. (The less the alpha power, the greater the activation.)

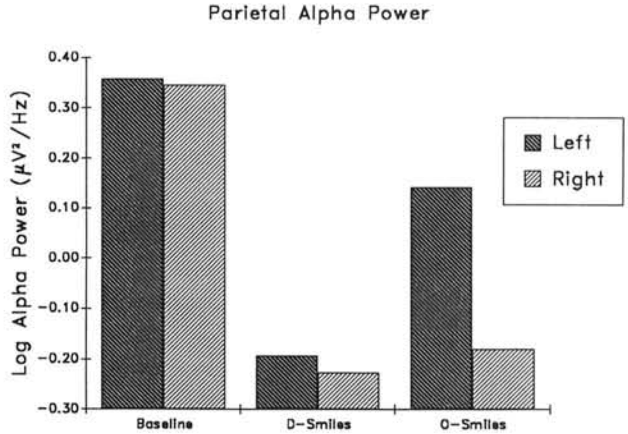

Figure 6. Mean alpha power in the left and right parietal regions (P3 and P4, respectively) for the baseline condition and during Duchenne's smiles and other smiles.

composed this interaction, we found that for this region, the Condition (D-smile–O-smile) × Hemisphere interaction for the direct comparison between smile types was significant, $F(1, 12) = 5.72, p = .03$, and no main effects were obtained. As Figure 6 indicates, the D-smiles were associated with more left parietal activation compared with the O-smiles ($p < .01$). No significant difference between smile types was obtained in the right hemisphere. During D-smiles, the left and right parietal regions did not differ from one another. However, during O-smiles, the right parietal region was significantly ($p < .01$) more active than the left (i.e., showing less alpha power).

When comparisons between each of the smile types and baseline were made, a Condition × Hemisphere interaction was found only for the O-smile versus baseline comparison, $F(1, 12) = 7.23, p = .02$. Again, no significant main effects were obtained in this analysis. Compared to baseline, O-smiles were associated with a significant decrease in right parietal alpha activity ($p < .001$).

We did not have any specific a priori predictions regarding differences between smile types in central asymmetry. However, we examined asymmetry in this region because of its relation with motor production. If the differences in asymmetry between smile types were a function of differences in motor asymmetry between them, we would expect to find central asymmetry to differentiate between D-smiles and O-smiles. The overall ANOVA on the central data revealed no significant differences in asymmetry among the three conditions.

Beta Power

Some researchers have suggested that alpha and beta activity may reflect different components or types of activation (e.g., Ray & Cole, 1985). In previous work, we have found that when carefully matched tasks are compared on measures of EEG asymmetry, power is attenuated in the hemisphere putatively most activated by the task in all frequency bands. However, power reduction in the specialized hemisphere is most consistently found in the alpha band (Davidson et al., in press). To address this issue in the present study, we recomputed all of the major analyses with beta (13–20 Hz) power as the dependent measure. The Condition (baseline–D-smile–O-smile) × Hemisphere interaction was not significant for frontal, $F(2, 24) = .44$; anterior temporal, $F(2, 24) = 1.61$; or central, $F(2, 24) = .79$, region activity. Nor were any main effects significant in these three regions. The Condition × Hemisphere interaction was significant for the parietal region, $F(2, 24) = 4.01, p < .04$, with Huynh–Feldt correction. Follow-up analyses indicated that this effect was a function of a significant Condition × Hemisphere interaction for the baseline versus other smile comparison, $F(1, 12) = 6.82, p < .03$. Paired comparisons revealed that this interaction was a function of other smiles eliciting less beta activity compared with baseline in the right hemisphere ($p < .05$). No difference between conditions was found in the left hemisphere.

Discussion

We have found consistent evidence supporting Ekman and Friesen's (1982) proposal for distinguishing among types of smiling rather than treating smiles as a single class of behavior. Specifically, the Duchenne smile was found, as predicted, to be related to enjoyment—in terms of when it occurs and how it relates both to subjective experience and distinctive physiological changes—and other smiling was not. Clearly the Duchenne smile, in which the orbicularis oculi, pars lateralis muscle that orbits the eye is contracted in addition to the zygomatic major muscle's pull on the lip corners, is a better sign of enjoyment than other kinds of smiles. A number of other investigators following Ekman and Friesen's suggestion have also found evidence that the Duchenne smile is associated with enjoyment in psychiatric patients (Krause et al., 1989; Matsumoto, 1986; Steiner, 1986), in infants (Fox & Davidson, 1988), in children (von Salisch, 1989), and in normal adults (Ruch, 1987).

Ekman and Friesen (1982) predicted that Duchenne smiles are the signal for any of the positive emotions, such as amusement, relief, contentment, satisfaction with achievement, or sensory pleasure, as well as the more general positive emotion terms such as enjoyment or happiness. The stimulus films we used to arouse positive emotions showed amusing events, not other types of positive emotions, and as expected, Duchenne smiles correlated with the report of amusement rather than contentment. Although Duchenne smiles also were correlated with reports of the more general term *happiness*, partial correlations showed that this was due to the correlation between happiness and amusement ratings. If other situations were examined in which the subjects experienced relief, contentment, or sensory pleasure rather than amusement, we would expect D-smiles to correlate with the subjective experience of those emotions, not amusement, but this remains to be demonstrated.

Although Watson and Tellegen (1985) included interest and excitement in their positive mood scale, we and other emotion theorists (Tomkins, 1962; Woodworth, 1938) consider interest and excitement as separate states that may or may not be accompanied by positive emotions. Our finding that Duchenne smiles were unrelated to reports of interest or excitement when the influence of amusement or happiness ratings was partialled out provides some support for our position. This finding does not necessarily contradict Watson and Tellegen, however, because they examined self-reports of moods, and we examined the relationship between momentary expression and momentary reports of emotion.

The question might be raised as to why other smiles occurred at all during the positive film if these are not enjoyment smiles. Our measurements did not distinguish among but instead combined the various kinds of other smiles (Ekman, 1985, has described 17 types of other smiles that are said to differ from each other in appearance). We expected that a particular type of other smile would occur when watching the puppy and primates films. These are what we have described as "anticipatory smiles," in which the person is anticipating but not yet experiencing enjoyment. It is also possible that other smiles may be a sign of less intense enjoyment. We also expected that some of the other smiles would include facial actions associated with negative emotions. In fact, a majority of subjects included in the EEG analyses had facial action units associated with negative affect in their other smiles. Such expressions may have been shown by those subjects who reported, in postexperiment interviews, negative emotional reactions to what they interpreted as teasing of the puppy or the confinement of apes in a zoo. The EEG data during other smiles certainly support the possibility that at least when they occur when watching the positive films, the other smiles are actually a sign of negative affect. Other research in which the subjective report of emotion is obtained immediately after the appearance of the smile, and in which more samples of different kinds of other smiles are examined in relation to the measures of cerebral asymmetry, is needed to further explore these possibilities.

The amount of Duchenne smiling also was related to differences among positive affect experiences, not just the grosser distinction between positive and negative affect. Making such a subtle distinction as to which of two positive experiences is the most positive was not possible based on other smiling.

It is worth noting that the subjects were alone when they were watching the films and did not know they were being videotaped or observed. As predicted, facial expressions did occur in this solitary situation. These expressions were not random, but instead were related to the type of film viewed, the subjective report, and physiology. In this respect these data are consistent with earlier reports that facial expressions of emotion do occur when people are alone (Ekman, 1972; Ekman et al., 1980) and contradict the theoretical proposals of those who view expressions solely as social signals. This is not to suggest that our findings mean that emotional experience or expression has nothing to do with social interaction. It is only that emotions can occur when one is alone as well as when one is with others. Obviously, it is the actions of others that most often bring forth an emotion. More specifically, the presence of others who are also experiencing enjoyment typically will increase enjoyment expressions, even when the source of the enjoyment is not a conversation but an activity such as watching a film.

The cerebral asymmetry findings indicate that, as predicted, the two types of smiling differ in the pattern of regional brain activity with which each is associated. Duchenne smiles are associated with more left-sided anterior temporal and parietal activation compared with other smiles. Although the left-sided anterior temporal activation was predicted to accompany positive affect, it is not clear what activation of the left parietal region might reflect in this study. Other EEG asymmetry studies have found that verbal cognitive activity reliably increases left parietal activation (e.g., Davidson et al., in press; Ehrlichman & Wiener, 1979). It is therefore possible that in the present context, the Duchenne smiles were accompanied by more verbal thinking compared with other smiles. In future studies it would be useful to assess cognitive activity in addition to experienced emotion, in order to evaluate this suggestion. The lack of any difference in central EEG activity between the Duchenne smiles and other smiles suggests that the differences in asymmetry between these smile types that were seen in other regions are not a function of differences in motor asymmetry, because central EEG asymmetries are very sensitive to motor differences between the two sides of the body (e.g., Coles, Gratton, Bashore, Eriksen, & Donchin, 1985; Kutas & Donchin, 1974).

Other smiles show a pattern of activation asymmetry similar to what has been reported for withdrawal-related negative affect (see Davidson et al., 1990). In fact, when we examined other smiles, we found that the majority did contain facial actions denoting negative emotion.

Contrary to prediction, Duchenne smiles did not differ significantly from baseline. This is the same pattern as was found for happy facial expressions in the accompanying article (Davidson et al., 1990). Davidson (1984) has reasoned that positive emotion is associated with left-sided anterior activation relative to a baseline only when the positive emotion is accompanied by approach behavior. As we noted in the accompanying article (Davidson et al., 1990), not all forms of positive affect include an approach component. The Duchenne smile marks a number of rather different positive affective states, not all of which involve approach. For example, contentment may not involve either approach or withdrawal. Amusement may involve approach (when it develops in response to a comedian unfolding a funny joke), or it may not, as we believe happened when subjects were amused watching our films of a dog, monkeys, and gorillas playing. The reason for our failure to find a difference in anterior asymmetry between Duchenne smiles and baseline may be that in this context, the Duchenne smile marked a form of positive affect with little or no approach component. In studies where unambiguous indices of approach behavior accompanied positive affect (i.e., an infant reaching toward its mother and smiling), significant left anterior activation was observed relative to a preceding comparison condition (Fox & Davidson, 1987, 1988). In the accompanying article, we offer several suggestions for how to measure "approach" happiness so that this form of positive affect can be compared with other nonapproach forms of positive affect, such as the type of amusement elicited in this study. We also make clear that our idea that the amusement aroused in our experiment did not involve approach is admittedly ad hoc. We offer other alternative interpretations of our data, and explain why we believe they are less tenable.

The analysis of beta power activity revealed little. As expected, the majority of the significant effects were in the alpha band. The only finding to reach significance for beta power was the difference in asymmetry between baseline and other smiles in the parietal region. The direction of this difference was identical to that found in alpha power—more power suppression in the right hemisphere during other smiles compared with baseline. The fact that alpha and beta power change in the same direction is consistent with other findings from our laboratory on EEG asymmetries in these bands in response to well-matched cognitive tasks (Davidson et al., in press).

Quite apart from what we have learned about the Duchenne smile as an index of enjoyment, our study also showed the feasibility and value of obtaining multiple measures in the study of emotion. Measures of facial expression were related to self-report and to different patterns of concomitant brain activity. In another report (Davidson et al., 1990) we extend our focus beyond smiles, considering negative facial expressions as well as positive ones, and again show the value of combining expressive and physiological measures in the study of emotion.

References

Andrew, R. J. (1963). Evolution of facial expression. *Science, 141,* 1034–1041.

Birdwhistell, R. L. (1963). The kinesic level in the investigation of emotions. In P. H. Knapp (Ed.), *Expression of the emotions in man* (pp. 123–139). New York: International Universities Press.

Birdwhistell, R. L. (1970). *Kinesics and context.* Philadelphia: University of Pennsylvania Press.

Blurton Jones, N. G. (1972). Non-verbal communication in children. In R. A. Hinde (Ed.), *Nonverbal communication* (pp. 271–296). Cambridge: Cambridge University Press.

Brannigan, C. R., & Humphries, D. A. (1972). Human nonverbal behavior, a means of communication. In N. G. Blurton Jones (Ed.), *Ethological studies of child behavior* (pp. 37–64). Cambridge: Cambridge University Press.

Bruner, J. S., & Tagiuri, R. (1954). The perception of people. In G. Lindzey (Ed.), *Handbook of social psychology* (Vol. 2, pp. 634–654). Reading, MA: Addison-Wesley.

Clark, L. A., & Watson, D. (1988). Mood and the mundane: Relations between daily life events and self-reported mood. *Journal of Personality and Social Psychology, 54,* 296–308.

Coles, M. G. H., Gratton, G., Bashore, T. R., Eriksen, C. W., & Donchin, E. (1985). A psychophysiological investigation of the continuous flow model of human information processing. *Journal of Experimental Psychology: Human Perception and Production, 11,* 529–553.

Darwin, C. (1955). *The expression of the emotions in man and animals.* New York: Philosophical Library. (Original work published 1872)

Davidson, R. J. (1984). Affect, cognition and hemispheric specialization. In C. E. Izard, J. Kagan, & R. Zajonc (Eds.), *Emotion, cognition and behavior* (pp. 320–365). New York: Cambridge University Press.

Davidson, R. J. (1987). Cerebral asymmetry and the nature of emotion: Implications for the study of individual differences and psychopathology. In R. Takahashi, P. Flor-Henry, J. Gruzelier, & S. Niwa (Eds.), *Cerebral dynamics, laterality and psychopathology* (pp. 71–83). New York: Elsevier.

Davidson, R. J., Chapman, J. P., Chapman, L. P., & Henriques, J. B. (in press). Asymmetrical brain electrical activity discriminates between psychometrically matched verbal and spatial cognitive tasks. *Psychophysiology.*

Davidson, R. J., Ekman, P., Saron, C., Senulis, J., & Friesen, W. V. (1990). Approach-withdrawal and cerebral asymmetry: Emotional expression and brain physiology I. *Journal of Personality and Social Psychology, 58,* 330–341.

Diener, E., & Emmons, R. A. (1984). The independence of positive and negative affect. *Journal of Personality and Social Psychology, 47,* 1105–1117.

Duchenne, B. (in press). *The mechanism of human facial expression or an electro-physiological analysis of the expression of the emotions* (A. Cuthbertson, Trans.). New York: Cambridge University Press. (Original work published 1862)

Ehrlichman, H., & Wiener, M. S. (1979). Consistency of task-related EEG asymmetries. *Psychophysiology, 16,* 247–252.

Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska Symposium on Motivation, 1971* (pp. 207–283). Lincoln: University of Nebraska Press.

Ekman, P. (1977). Biological and cultural contributions to body and facial movement. In J. Blacking (Ed.), *The anthropology of the body* (pp. 34–84). London: Academic Press.

Ekman, P. (1985). *Telling lies.* New York: W. W. Norton.

Ekman, P. (1989). The argument and evidence about universals in facial expressions of emotion. In H. Wagner & A. Manstead (Eds.), *Handbook of psychophysiology: The biological psychology of emotions and social processes* (pp. 143–164). London: John Wiley Ltd.

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

Ekman, P., & Friesen, W. V. (1974). Detecting deception from body or face. *Journal of Personality and Social Psychology, 29,* 288–298.

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

Ekman, P., & Friesen, W. V. (1976). Measuring facial movement. *Journal of Environmental Psychology and Nonverbal Behavior, 1,* 56–75.

Ekman, P., & Friesen, W. V. (1978). *The facial action coding system.* Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1982). Felt, false, and miserable smiles. *Journal of Nonverbal Behavior, 6,* 238–252.

Ekman, P., Friesen, W. V., & Ancoli, S. (1980). Facial signs of emotional experience. *Journal of Personality and Social Psychology, 39,* 1125–1134.

Ekman, P., Friesen, W. V., & O'Sullivan, M. (1988). Smiles when lying. *Journal of Personality and Social Psychology, 54,* 414–420.

Ekman, P., Friesen, W. V., & Simons, R. C. (1985). Is the startle reaction an emotion? *Journal of Personality and Social Psychology, 49,* 1416–1426.

Ekman, P., Roper, G., & Hager, J. C. (1980). Deliberate facial movement. *Child Development, 51,* 886–891.

Fox, N. A., & Davidson, R. J. (1986). Taste-elicited changes in facial signs of emotion and the asymmetry of brain electrical activity in human newborns. *Neuropsychologia, 24,* 417–422.

Fox, N. A., & Davidson, R. J. (1987). Electroencephalogram asymmetry in response to the approach of a stranger and maternal separation in 10-month old children. *Developmental Psychology, 23,* 233–240.

Fox, N. A., & Davidson, R. J. (1988). Patterns of brain electrical activity during facial signs of emotion in 10-month old infants. *Developmental Psychology, 24,* 230–236.

Grant, N. G. (1969). Human facial expression. *Man, 4,* 525–536.

Hunt, W. A. (1941). Recent developments in the field of emotion. *Psychological Bulletin, 38,* 249–276.

Krause, R., Steimer, E., Sanger-Alt, C., & Wagner, G. (1989). Facial expression of schizophrenic patients and their interaction partners. *Psychiatry, 52,* 1–12.

Kraut, R. E. (1978). Verbal and nonverbal cues in the perception of lying. *Journal of Personality and Social Psychology, 36,* 380–391.

Kutas, M., & Donchin, E. (1974). Studies of squeezing: Handedness, responding hand, response force, and asymmetry of readiness potential. *Science, 186,* 545–548.

LaBarre, W. (1947). The cultural basis of emotions and gestures. *Journal of Personality, 16,* 49–68.

Landis, C. (1924). Studies of emotional reactions: II. General behavior and facial expression. *Journal of Comparative Psychology, 4,* 447–509.

Lee, G. P., Loring, D. W., Meador, K. J., & Flanigin, H. F. (1988, January). *Emotional reactions and behavioral complications following unilateral intracarotid sodium amytal injections.* Paper presented at the annual meeting of the International Neuropsychological Society, New Orleans.

Lindsley, D. B., & Wicke, J. D. (1974). The electroencephalogram: Autonomous electrical activity in man and animals. In R. Thompson & M. N. Patterson (Eds.), *Bioelectric recording techniques* (pp. 3–79). New York: Academic Press.

Malatesta, C. Z., & Kalnok, D. (1984). Emotional experience in younger and older adults. *Journal of Gerontology, 39,* 301–308.

Matsumoto, D. (1986). *Cross-cultural communication of emotion.* Unpublished doctoral dissertation, University of California, Berkeley.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh Inventory. *Neuropsychologia, 9,* 97–113.

Ray, W. J., & Cole, H. C. (1985). EEG alpha activity reflects attentional demands, and beta activity reflects emotional and cognitive processes. *Science, 228,* 750–752.

Robinson, R. G., Kubos, K. L., Starr, L. B., Rao, K., & Price, T. R. (1984). Mood disorders in stroke patients: Importance of location of lesion. *Brain, 107,* 81–93.

Rossi, G. F., & Rosadini, G. (1967). Experimental analysis of cerebral dominance in man. In C. H. Millkan & F. L. Darley (Eds.), *Brain mechanisms underlying speech and language* (pp. 167–184). New York: Grune and Stratton.

Ruch, W. (1987, June). *Personality aspects in the psychobiology of humor laughter.* Paper presented at the third meeting of the International Society for the Study of Individual Differences, Toronto.

Silberman, E. K., & Weingartner, H. (1986). Hemispheric lateralization of functions related to emotion. *Brain and Cognition, 5,* 322–353.

Smith, W. J. (1985). Consistency and change in communication. In G. Zivin (Ed.), *The development of expressive behavior* (pp. 51–75). Orlando, FL: Academic Press.

Steiner, F. (1986). Differentiating smiles. In E. Branniger-Huber & F. Steiner (Eds.), *FACS in psychotherapy research* (pp. 139–148). Zurich: Department of Clinical Psychology, Universitat Zurich.

Stone, A. A. (1981). The association between perceptions of daily experiences and self- and spouse-rated mood. *Journal of Personality and Social Psychology, 15,* 510–522.

Tagiuri, R. (1968). Person perception. In G. Lindzey & E. Aronson (Eds.), *Handbook of social psychology* (pp. 395–449). Reading, MA: Addison-Wesley.

Tomkins, S. S. (1962). *Affect, image, consciousness. Volume 1. The positive affects.* New York: Springer.

Tucker, D. M., & Frederick, S. L. (1989). Emotion and brain lateralization. In H. Wagner & T. Manstead (Eds.), *Handbook of psychophysiology: Emotion and social behaviour* (pp. 27–70). London: Wiley.

von Salisch, M. (1989). *Kinderstreit-kinderleid, ausdruck und kommunikation von gefuheln wahrend eines konfliktes unter befreundeten kindern.* Unpublished doctoral dissertation, Freie Universitat Berlin.

Watson, D., & Tellegen, A. (1985). Toward a consensual structure of mood. *Psychological Bulletin, 98,* 219–235.

Woodworth, R. S. (1938). *Experimental psychology.* New York: Henry Holt.

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