Ann. Rev. Psychol. 1989. 40:249–80

FACIAL EFFERENCE AND THE EXPERIENCE OF EMOTION

Pamela K. Adelmann and R. B. Zajonc

Department of Psychology and the Research Center for Group Dynamics, The University of Michigan, Ann Arbor, Michigan 48109

CONTENTS

INTRODUCTION

In this review, we consider the nature and role of facial expression in emotional processes. We examine the recent theoretical and empirical literature for its bearing on the questions of the proximal and distal correlates of facial emotional actions, particularly on the question of their modulating and initiating functions in the experience of emotion. We emphasize the role of emotional facial action in the subjective experience of emotion.

We avoid in this paper the convention of referring to emotional facial action as "expression" since that term imposes an a priori theory, implying that

0066–4308/89/0201–0249$02.00

emotional facial action (facial efference) has as its major role the manifestation of internal states. This as the primary role of facial action has not been established as an empirical fact, and thus it is best for now to employ a term that does not prejudge the outcome of empirical and theoretical analysis. While the term "facial efference" is less agile and less common, it has the advantage of being neutral with respect to the kind of principles that would be called upon to explain it.

Before examining the empirical evidence on facial efference and its correlates, we briefly review the major theoretical perspectives on facial efference: sensory, evolutionary, and facial feedback.

Pre-Darwinian Sensory Theories of Emotion

Two physiologists working at the second half of the 19th century, Theodor Piderit (1858, 1888) and Pierre Gratiolet (1865), based the explanation of facial emotional action on the sensory system. According to both theories, facial movements are generalizations of peripheral muscular actions elicited in the course of the sensory and perceptual process. Thus, the facial action accompanying the emotion of disgust is similar to that occurring when the individual reacts to an unsavory taste. Both theories point out that peripheral movements can also be elicited by imagination; for example, ocular accommodation and convergence show different patterns when one thinks of threading a needle than when one imagines a ship on the horizon. Gratiolet (1865) noted the close affinity between *sensation* and *sentiment,* where the former dealt with stimuli that came from the exterior whereas the latter with those that came from the interior. Sentiment, or *sens intime* is an experience that originates within the organism, and as such it constitutes the basic element of emotion. He also distinguished *symbolic* and *metaphoric* movements, where the former is illustrated by a bowler's movement following his bowling ball and the latter by the gesture of contempt that is a metaphor for a reaction to an unpleasant odor.

Gratiolet held that "no sensation, image, or thought . . . can occur without evoking a correlated sentiment which translates itself directly . . . into all spheres of external organs . . . " (1865, p. 65). More interestingly, however, he insisted that the converse is equally true. "The movements and bodily attitudes," he wrote (p. 66), "even if they arise from fortuitous causes, evoke correlated sentiments, which in turn influence imagination, feeling, and thought."

Gratiolet did not refer to Piderit, whose theory was strikingly similar, although Piderit (1888) claims to have presented his ideas in Paris in 1859 at a meeting of the Biological Society, of which Gratiolet was a member and which publishes the *Gazette Médicale,* which printed Piderit's presentation in issue #46.

Evolutionary Theory of Emotion

Darwin's views on the communicative and adaptive function of facial efference, being well known, need not be described here. It is worth noting, however, that he rejected both Piderit's and Gratiolet's writings. He says of the latter, "Although Gratiolet emphatically denies that any muscle has been developed solely for the sake of expression, he seems never to have reflected on the principle of evolution" (1896, p. 11). And to Piderit, who sent his book to Darwin, the latter wrote:

> I have a copy and know of your work on Mimic, etc. which I have found very useful and often quote. But I am a poor German scholar and your style. . . . I find very difficult to understand. Accordingly I employed a man to translate for me several pages. These I have given in my introduction, in order to state, as far as possible by a few sentences, your views. I fear that I may not do you full justice, but assuredly I tried my best to do it (Piderit 1888, pp. 7–8).

In reference to this letter, Piderit says that even if Darwin had known German better he would not have paid more attention to the sensory theory of emotional expression because, as in other work, Darwin was only interested in discovering new evidence for his theory of evolution ["Darwin ne cherche ici, comme dans tous ses autres travaux, qu'à découvrir de nouveaux documents en faveur de sa théorie de l'évolution" (1888, pp. 7–8).] Piderit's perception of Darwin's motives seems accurate, as Darwin concludes his book by asserting that emotional expression is indeed a further demonstration of how "man is derived from some lower animal form" (1896, p. 365).

Despite Darwin's preeminent interest in promoting evolutionary theory in his work on emotion, his admission of a possible causal role of efference in the emotional experience foreshadowed the development of the facial feedback hypothesis. "The free expression by outward signs of an emotion intensifies it," he wrote. "On the other hand, the repression, as far as this is possible, of all outward signs softens our emotions" (1896, p. 365).

Development of the Facial Feedback Hypothesis

JAMESIAN THEORY The facial feedback theory of emotional efference derives in part from William James, who in proposing his famous theory of emotion in 1884 introduced the possibility of a causal role of the face in the experience of emotion. His often quoted statement that "the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur is the emotion" (p. 13, 1922) was frequently construed later by critics to include only, or primarily, visceral changes as feedback. Yet in his original formulation of the feedback theory he named not only visceral but respiratory, cutaneous, and circulatory alterations. In addition, he wrote, "what is really equally prominent, but less likely to be

admitted until special attention is drawn to the fact, is the continuous cooperation of the voluntary muscles in our emotional states. Even when no change of outward attitude is produced, their inward tension alters to suit each varying mood, and is felt as a difference of tone or of strain" (p. 15). Even in his somewhat revised statement in *The Principles of Psychology* (1890), the role of muscles in the experience of emotion was not discounted as thoroughly as his critics contended (e.g. Cannon 1927, 1931). He continued to refer to the "indefinitely numerous" and "the immense number" of bodily reverberations corresponding to each emotion, including among them visceral, muscular, and cutaneous effects.

As for the facial musculature, although he did not specifically distinguish it from the skeletal musculature as a source of feedback in emotional experience, virtually every example James employed to illustrate his hypothesis included some reference to facial efference. "Smooth the brow, brighten the eye, contract the dorsal rather than the ventral aspect of the frame, and speak in a major key, pass the genial compliment, and your heart must be frigid indeed if it does not gradually thaw!" he wrote (p. 1078). And, he asked, "Can one fancy the state of rage and picture no ebullition in the chest, no flushing of the face, no dilatation of the nostrils, no clenching of the teeth . . ." (p. 1067–68)?

Even so, in his most specific reference to facial efference in *The Principles*, James admitted that its influence in the generation of feeling was overshadowed by the corresponding visceral and organic components of emotion. Anticipating the criticism that among actors and others with extensive practice in posing facial emotional actions, voluntary efference does not always produce subjective feeling, he argued that these highly trained individuals may have learned to suppress the "natural association" between efference and the visceral and organic components of emotion, on the latter of which "it is probable that the chief part of the felt emotion depends" (p. 1080). For less practiced individuals, he seemed to believe that voluntarily effecting the "so-called manifestations" of an emotion ought to give rise to that emotion. He also admitted, "We may catch the trick with the voluntary muscles, but fail with the skin, glands, heart, and other viscera. Just as an artificially initiated sneeze lacks something of the reality, so the attempt to imitate an emotion in the absence of its normal instigating cause is apt to be rather 'hollow'" (p. 1066).

Although James ascribed to the skeletal musculature a lesser role in initiating emotion than other organs, he nevertheless clearly included this source of feedback as an integral component of his theory. In 1890 as in his earlier formulation, he proposed four steps in the generation of subjective experience of emotion: a sensory stimulus (of either external or internal origin) is transmitted to the cortex and perceived; reflex impulses travel to muscle, skin,

and viscera; the resulting alterations in these targets are transmitted via afferent pathways back to the brain; these return impulses are then cortically perceived, and when combined with the original stimulus perception, produce the "object-emotionally-felt."

Sherrington (1900) and Cannon (1915, 1927, 1931), however, seized on James's admission that felt emotion may rely more heavily on visceral and organic than other components as the basis of their attacks on his theory. Drawing on animal research, they built a convincing argument that visceral feedback was an inadequate determinant of emotion. Sherrington (1900) cited his research on animals in which the autonomic nervous system afferent pathways from the shoulders down were destroyed, thus eliminating feedback from the viscera. When presented with an emotion stimulus, the dogs reacted with all appearance of a normal "emotional psychosis," including facial efference, head and foreleg movements, and vocalizations. His recommendation was therefore to "accept visceral and organic sensations and the memories and associations of them as contributory to primitive emotion, but we must regard them as reenforcing rather than initiating the psychosis" (p. 258).

Cannon (1927) developed a five-point attack on the Jamesian theory. Like Sherrington, he named the animal research showing an unimpaired emotional reaction in the absence of visceral feedback (Cannon 1915). He also argued that visceral changes—heart rate acceleration, inhibition of digestive activity, sweating, and others—occur uniformly across a variety of emotional states and are too diffuse to discriminate among them. The viscera are relatively insensitive structures, he continued, and changes in them are much slower than the average latent period of an affective reaction. Finally, he argued that artificial induction by adrenalin of emotion-like visceral changes does not produce the subjective experience of an emotion unless a mood is already present.

The attacks by Sherrington and Cannon brought a stream of response from people such as Angell (1916), Floyd Allport (1924), and Perry (1926), who in rising to James's defense offered theoretical interpretations placing more emphasis on the role of the skeletal musculature in emotion. Angell, for example, declared that James "nowhere set himself the task of attempting to differentiate emotions on exactly the basis suggested by Dr. Cannon's statement" (1916, p. 259). James would have agreed, he contended, that in some emotions identical patterns of visceral excitement might occur, but might have then argued that "their distinction from one another in such cases may be found in extra-visceral conditions, and particularly in the tonus of the skeletal muscles" (p. 260). He further argued, of Sherrington's head-and-shoulder dogs, that "no evidence which left facial and cranial muscles unimpaired would ever have seemed to him very convincing as ground for conclusions unfavorable to his theory" (p. 261). Perry (1926), in a similar vein, responded

to Cannon that distinctions among emotions "may lie in the proprioceptive rather than in their interoceptive patterns; that is to say, in the motor set rather than in the visceral reverberation" (pp. 300–1).

Allport (1924) argued that although the autonomic nervous system may not discriminate among discrete emotions, it does differentiate the class of positive emotions from the negative. He assigned to the cranio-sacral division responsibility for the "conscious quality of pleasantness," and to the sympathetic division the "visceral responses which are represented in consciousness as unpleasant" (p. 90). Further, Allport proposed that within a single affective class "the differentiating factor arises from the stimulation of the proprioceptors in the muscles, tendons, and joints of the somatic part of the organism; and that afferent impulses from these somatic patterns of response add to the autonomic core of affectivity the characteristic sensory complexes by which one emotion is distinguished from another" (pp. 91–92). To this he added that "the facial expressions as well as bodily movements are strongly differential" (p. 92).

Indeed, Cannon had a more difficult time in dismissing the muscular component of James's theory. He claimed simply that "sensations which underlie the appreciation of posture are entirely lacking feeling-tone" (1927, p. 119). He acknowledged that motor attitude seems to influence subjective experience, but argued that instead of providing sensory feedback, certain postures remove the usual motor cortex inhibition of the thalamus, the structure at the center of his theory of emotion, thus facilitating subjective experience.

Neither James's critics nor his defenders defined a specific role of the facial muscles in emotion, a definition that was not to appear for several decades. But in the interim, Nina Bull proposed her Attitude Theory of Emotion (Bull 1951; Pasquarelli & Bull 1951), which revived and extended the muscular aspect of Jamesian theory.

THE ATTITUDE THEORY In the *Attitude Theory,* Bull argued that confusion about whether bodily change or subjective experience comes first was due to a failure to separate emotional efference into its component parts. James was mistaken, she explained, only in that he focused on the action component rather than on the preparatory motor attitude: "We feel angry as a result of readiness to strike, and feel afraid as a result of readiness to run away, and not because of actually hitting out or running, as James explained the sequence" (1951, p. 6).

Bull postulated that the involuntary postural attitudes preparatory to action are accompanied by appropriate organic changes, and that "feelings of these organic changes combine with the feelings of the orienting posture itself—and with some awareness of the original exciting stimulus—to produce the famil-

iar experience known as an 'emotion'" (p. 5). She further suggested that feeling "may follow and accompany a motor attitude, but does not necessarily do so; and cannot possibly precede it—cannot in fact appear at all without an antecedent motor attitude to fire the afferent pathways from the muscles and viscera to the brain" (p. 19).

To test the Attitude Theory, Pasquarelli & Bull (1951) first induced in subjects an emotion and its corresponding motor attitude through hypnosis, using such directions as these (for anger): "Your hands are getting tense and your arms are getting tense. You can feel your jaw tightening." They then "locked" this attitude, and suggested the feeling, but not the attitude, of a contrasting emotion. In some trials an unpleasant emotion (disgust, anger, fear, or depression) was locked and a pleasant one (joy, triumph) suggested and on the others the reverse sequence was followed.

Without exception, subjects reported they could not successfully "feel" the suggested emotion while locked in the contrasting attitude. Those who changed their feeling to the new emotion could do so only by disobeying the suggestion prohibiting changes in efference or organic sensation.

Like those who preceded her, Bull did not assign a special role to the face, although the hypnotic suggestions to subjects included instructions for facial as well as bodily motor attitude. But within the next decade, emotion theorists began to postulate a specific and central role of the facial musculature in the experience of emotion. These postulates, embedded within comprehensive theories of emotion, came to be known as the facial feedback hypotheses.

FACIAL FEEDBACK HYPOTHESES First among these theorists was Silvan Tomkins, who in a wide-ranging two-volume set of books (1962, 1963) introduced the notion of facial feedback. "Most contemporary investigators have pursued the inner bodily responses, after the James-Lange theory focused attention on their significance," he explained. "Important as these undoubtedly are, we regard them as of secondary importance to the expression of emotion through the face. . . . the face expresses affect, both to others, and to the self, via feedback, which is more rapid and more complex than any stimulation of which the slower moving visceral organs are capable" (1962, pp. 205–6). As providing feedback from the face he listed the tongue and facial muscles, the sound of one's own voice in the ears, and changes in blood-flow and temperature of the face. He futher regarded the facial muscles as more informative of affective state than those of the trunk and extremities, thereby making a clear statement about the face apart from the other skeletal muscles.

Tomkins built his case for the primacy of the face upon several arguments. First, he argued the face is the most sensitive and dominant part of the body, with a high density of "neural representation and firing" (1962, p. 208). He

noted that in contrast to other responses, involuntary facial responses are highly resistant to habituation. In addition, the facial muscles lack a fascial cover that binds muscles elsewhere in the body together into groups, so that in the face, "smaller muscle portions or even single muscle bundles may contract independently of the rest of the muscle" (p. 225) in a variety of complex patterns.

In the Tomkins feedback cycle, a stimulus activates an innate, subcortical "affect program," which emits messages through the motor and circulatory pathways to the entire body. The responses of the affected motor and glandular targets—the face primarily, other sites secondarily—supply sensory feedback to the brain, which, if it reaches consciousness, is subjectively experienced as emotion. Tomkins argued that this feedback may be acted upon whether or not it reaches awareness, that voluntary facial efference may not accurately duplicate the innate pattern, and that the sequence may be initiated by retrieved conscious affect or central imagery as well as by an external emotion stimulus.

He later modified his theory somewhat to downplay the facial muscles ["Muscles appear to be specialized for action and not for affect" (1980, p. 149)] and focused instead on the facial skin as playing the greatest role in producing feelings of affect. He specifically argued that in an expressive face, receptors normally hidden in the skin change position in response to the facial muscle patterns; the feedback is therefore from these cutaneous receptors rather than from the muscles of the face.

Both muscles and skin played important roles in Gellhorn's (1964) view of facial feedback, and both bodily and facial muscles were assigned important roles. Gellhorn argued that body posture influences affective arousal through the proprioceptive discharges feeding back to alter hypothalamic balance. But because such diverse states as happiness and tenseness are both associated with increased proprioceptive postural discharges, while low muscle tone accompanies sadness as well as "postprandial happiness," he considered the proprioceptive feedback provided by bodily posture to be insufficient to distinguish among discrete emotions. For this differentiating information he turned to the face.

"The great density of the cutaneous receptors in the face and the considerable variety of the patterns of contraction of the facial muscles suggest that the resulting patterns of neocortical excitation and hypothalamic-cortical discharges will match in diversity that of the emotional expression," he wrote (1964, p. 465). He argued that the proprioceptive facial-muscle discharges arouse the hypothalamic-cortical system, while tactile impulses are conveyed to sensorimotor cortex. In combination, these two sources of feedback "play an important role in the development of the emotions and a subsidiary role in their reinforcement after they have been established," he claimed (p. 468).

Izard voiced a similar view in his Differential Emotions Theory (1971). He contended that the primary components of emotion are neural activity, striate muscle or facial-postural activity, and subjective experience, augmented by the brain stem reticular system and the glandular-visceral system. In his sequence of events, a stimulus perception activates central neural activity (in an unknown order to the brain stem, hypothalamus, and limbic cortex), producing a global pleasant or unpleasant feeling. The hypothalamus signals the smooth and striate muscles (perhaps in a discrete emotion-specific pattern to the face). The specificity of the facial muscle feedback to the brain stem, hypothalamus, limbic system, thalamus, and possibly cortex determines the specificity of the felt emotion. Feedback from the auxiliary systems (including visceral, glandular, cardiovascular, and respiratory) helps sustain and amplify the subjective experience. He added that for a specific facial pattern to match subjective experience, it must correspond to the original efferent pattern, the neural message must travel innate pathways for the emotion, and the feedback must be reasonably complete (e.g. slight or micromomentary efference may produce only fleeting awareness).

In sum, although their ideas varied somewhat in the particulars, these three theorists in quick succession proposed a specific and central role of the face in the experience of emotion. Their thoughts inspired a wealth of empirical research on the facial feedback hypothesis.

INVESTIGATING FACIAL FEEDBACK

In the course of empirical investigation of facial feedback, several versions of the hypothesis have evolved. The most basic, drawn directly from the theories of Tomkins, Gellhorn, and Izard, is considered first. It proposes simply that in the process of a naturally occurring emotional experience, there will be a correspondence between facial efference and subjective experience. Implicit in this version are the notions that strength of efference and intensity of subjective experience covary, and that specific efference patterns correspond with specific subjective states.

Although in the original facial feedback hypotheses autonomic arousal was assigned only an auxiliary role, at most amplifying or sustaining an emotional experience, others have pursued the Jamesian notion that facial efference patterns correspond with patterns of autonomic arousal as well. Thus, research has also addressed whether facial efference and arousal covary in intensity and whether arousal patterns are differential, at the least, for positive versus negative emotional efference patterns, and, at most, for a variety of discrete facial efference patterns. The correlational literature on facial efference, physiological arousal, and subjective experience addresses these questions arising from the original facial feedback hypotheses.

Correlational Studies of Facial Efference and Emotional Experience

In the correlational literature on facial feedback, external stimuli such as films, electric shock, and slides are most typically used as elicitors of facial emotional efference, but some researchers have had success using other techniques such as imagery and reinforcement. In general, only physiological or subjective correlates of facial efference have been measured, but in a few studies both types of information have been collected from the same subjects.

PHYSIOLOGICAL EXPERIENCE The literature on emotional efference and physiological arousal preceding the facial feedback hypotheses suggested that any correlation between facial expressivity and arousal would be negative. In most of this research (Prideaux 1920; Landis 1932; Jones 1948; Block 1957; Learmonth et al 1959), subjects who were most expressive showed little autonomic arousal, and those least expressive showed the most autonomic activity.

As a logical extension of this early research, initial studies on facial efference and physiological arousal adopted the same between-subjects methodology. Lanzetta & Kleck (1970), for example, were among the first to examine the association between facial efference and arousal in the context of a study on encoding and decoding ability. In their study, subjects undergoing shock trials were unknowingly videotaped. Their degree of facial expressiveness was determined by the ability of a set of judges to accurately discriminate shock from nonshock trials from the subjects' faces. Subjects with the highest galvanic skin responses (GSR), indicating sympathetic autonomic nervous system activity, were the least facially expressive, paralleling the inverse relationship between emotional expressivity and GSR reported by the earlier researchers.

Notarius & Levenson (1979), on the other hand, found no significant association between GSR responses and expressiveness of response to the threat of shock. But consistent with the general pattern, less facially expressive subjects showed greater heart rate and respiration rate responses to the threat than did more expressive subjects.

Buck et al (1972), in the context of research on nonverbal communication accuracy, looked at GSR and heart rate correlates of facial efference elicited by sexual, scenic, maternal, disgusting, unusual, and ambiguous slides. Expressivity of subjects was measured by how well observers could guess, from subjects' facial efference, the category and pleasantness of slides being viewed. Expressive subjects showed lower GSR than less expressive ones, but heart rates did not differ. Buck and colleagues (Buck et al 1974) replicated this study using male-female pairs of senders and observers as well as same-sex pairs. They again found lower GSR among more expressive sub-

jects (this time for men only) and no differences in heart rate in between-subjects comparisons. More recently, Buck (1977) found a negative association between indicators of expressivity and skin conductance in both male and female preschoolers in response to slides.

Why the degree of an individual's emotional expressivity, facial or otherwise, should inversely vary with autonomic arousal, has been explained in a number of ways. The basic discharge or cathartic-hydraulic view is that emotion must find an exit, and if it cannot be vented outwardly through efference, it must be routed inward. Jones (1948) labeled individuals who outwardly display emotion but show little arousal "externalizers;" those who behaviorally manifest little emotion but show substantial autonomic activity he called "internalizers." Lanzetta & Kleck (1970) proposed that individuals who are socialized to inhibit their outward emotional displays evidence increased arousal from the combination of redirected emotion and conflict experienced over competing tendencies to express and to inhibit emotion. Buck et al (1974) suggested that during the emotional socialization of such individuals, the stress of parental rebukes becomes associated with emotion-eliciting situations, and that the arousal they show may arise from this association rather than from evoked emotion. Buck also later suggested (1977) that innate determinants may play a role in whether an individual is an internalizer or externalizer.

What is important for the facial feedback hypothesis, however, is that the inverse relationship found between subjects does not rule out the possibility of a positive correlation between expressivity and arousal within subjects, as would be predicted by the hypothesis. In fact, in nearly all within-subjects analyses, that is the association that has been found.

Vaughan & Lanzetta (1980) recorded both autonomic arousal and facial expressivity as judged by activity in muscles around the eyes and jaw (indicating pain) of subjects watching a model's reactions to shocks. On shock trials, subjects showed both greater facial activity (resembling pain) and increased GSR, compared to nonshock trials.

Contradictory results have been reported in two studies with infants. Brock et al (1986) found that 3-month-old infants' smiles in reaction to a female experimenter corresponded with an increase in heart rate. But Cohen et al (1986) found in a study of 4-month-old infants' facial efference in response to their mothers' facial poses that infants' heart rate increased during anger efference but decreased when their faces showed interest and joy. Skin temperature was highest during angry faces and lower during joy.

Dimberg (1982) used photographs of emotional faces as stimuli and measured both heart rate and skin conductance responses. Happy face photographs produced increased zygomatic activity and angry photographs increased corrugator activity, indicating that subjects adopted happy and angry

facial patterns, respectively. Heart rate and skin conductance dropped in both patterns of emotional efference (and did not vary by emotion).

In the studies by Buck and colleagues noted earlier, greater facial activity in response to the stimulus slides corresponded with higher GSR reactivity within subjects (Buck et al 1972, 1974). In addition, GSR increased with the unpleasantness of an individual's facial reaction to slides (Buck 1977; Buck et al 1972, 1974), as did heart rate (Buck et al 1972, 1974).

The within-subjects research on physiological correlates of spontaneous facial efference is mixed. Indicators such as GSR and heart rate do not seem to consistently discriminate positive from negative facial affect, but they do appear to generally increase with intensity of facial efference.

SUBJECTIVE EXPERIENCE More directly pertinent to facial feedback hypotheses is whether subjective experience corresponds with facial efference. In contrast to the research on physiological correlates, greater facial expressivity is uniformly associated with greater subjective experience both between and within subjects, and the reported emotion tends to match the particular facial efference pattern in both valence and category.

In two between-subjects studies, Cupchik & Leventhal reported associations between facial expressive behavior and evaluations of cartoons in research on audience and sex effects. In one (1974), the intensity of spontaneous smiling and laughing at cartoons (manipulated by playing canned laughter) was correlated with higher funniness ratings by women but only for poor-quality cartoons for men. These results were replicated in a second study (Leventhal & Cupchik 1975) in which type of canned laughter was varied.

Kleinke & Walton (1982) manipulated subjects' spontaneous facial efference of happiness using reinforcement techniques. Subjects were not aware that this was influencing the amount they smiled, nor could they accurately guess how often they smiled during the study. Those who were reinforced to smile frequently reported more positive feelings and rated the interview and interviewer higher than did those not reinforced.

Ekman et al (1980) examined both positive and negative affect in a study using films as stimuli. Facial efference patterns were coded using their Facial Action Coding System (FACS). Subjects who showed a happiness facial action while watching positive films reported themselves as happier than those who did not show it, and the frequency, duration, and intensity of this action were positively correlated with self-reported happiness. On the other hand, subjects who showed facial actions of anger, fear, disgust, sadness, or contempt to a negative film reported more negative affect than those who did not, and frequency and duration of expressed negative emotion were correlated with greater self-reported negative affect. In particular, expressed and felt disgust were significantly related.

In several within-subjects analyses, facial efference patterns as assessed by electromyography (EMG) corresponded with self-reported mood. Teasdale & Bancroft (1977) compared corrugator EMG and depressed mood in a small sample of depressed subjects during happy and unhappy thoughts. The unhappy imagery increased both depressed mood and corrugator activity (negative facial efference) compared to happy thoughts, and depressed mood and corrugator activity were highly correlated. McHugo (1983) found that activity of the zygomatic muscles (happy facial efference) while watching positive films was correlated with positive self-reports, while corrugator activity during a negative film was linked to higher self-reported anger. In a third study (Cacioppo et al 1986), although observers could not discriminate the valence and intensity of subjects' facial displays to slides, EMG activity reliably did so; corrugator activity (anger) was higher for negative than positive self-reported affect, and the more the corrugator activity, the more negative the affect. Similarly, zygomatic responses corresponded with greater pleasant than unpleasant affect. In two experiments, Dimberg (1987b) also found that subjects' corrugator and zygomatic activity in reaction to pictured stimuli corresponded to negative and positive self-reports, respectively.

Schwartz and colleagues have published a number of studies on facial efference generated by imagery-induced affect and assessed with EMG. In a 1976 study, depressed and normal subjects imagining happy, sad, and angry situations generally showed the corresponding facial efference patterns and subjective reports for each emotion, although the magnitude of each response differed for depressed and normal subjects. In a normal student sample, Brown & Schwartz (1980) found increased self-reported happiness and happy facial patterns (zygomatic) following standardized happy imagery, and greater reported sadness and sad facial patterns (corrugator) following sadness imagery. Anger and corrugator activity, and fear and zygomatic activity followed the corresponding imagery for anger and fear. Differing intensities of imagery evoked parallel intensity of both facial activity and subjective experience. In another sample, self-reported happiness and zygomatic activity both increased with happy imagery, and self-reported sadness and corrugator activity resulted from sadness imagery (Schwartz et al 1980). Similar results were reported using self-referent statements to generate affect (Sirota et al 1987).

An imagery paradigm was also used by Sutherland et al (1984) in a sample of black women. Imagining fearful and racially derogatory scenes increased corrugator activity and reduced pleasantness ratings compared to imagining a neutral scene.

Only one report departed from this consistent positive association between facial efference and subjective experience. Kleinke & Walton (1982) found in a within-subjects analysis of their data (for both subjects who were reinforced

for smiling and nonreinforced subjects) that amount of smiling was not significantly correlated with self-reported positive feelings.

PHYSIOLOGICAL AND SUBJECTIVE EXPERIENCE Finally, in several studies both physiological and self-report correlates of facial efference were assessed in the same subjects. Three of these involved between-subjects tests. In the first, researchers divided their sample into groups varying in rated facial expressivity (Notarius et al 1982). In reaction to an angry scolding by an experimenter, minimally expressive subjects showed a significant heart rate increase compared to both nonexpressive and highly expressive subjects, and reported significantly higher guilt feelings (but did not differ on nine other affect scales). In the second, Winton et al (1984) found no significant correlations of facial expressivity with heart rate or skin conductance in between-subjects analysis. Ridgeway & Waters (1987) found that children asked to think about exciting experiences showed more facial pleasure and heart rate variability than children in a calm-imagery group, and a sad-imagery group showed less facial pleasure and slightly less heart rate change than in the calm group.

When the relationship between facial efference and its correlates is examined within subjects, the picture again changes. Kleck and colleagues (1976) measured subjective and autonomic responses in a study on the impact of an observer on expressiveness. The presence of another reduced the expressive response to shock, and both subjective and autonomic responses decreased as well.

Subjects in a study by Dimberg (1987a) showed greater corrugator activity and skin conductance responses and more rated unpleasantness to a high-intensity tone than to one of low intensity. Heart rate decelerated to the low–but not the high-intensity tone.

As part of a larger study, McHugo et al (1985) showed subjects taped silent television segments of Ronald Reagan expressing happiness, fear, or anger. Subjects imitated the facial patterns, with elevated zygomatic activity during happy segments, elevated corrugator and reduced zygomatic activity during anger segments, and both moderately raised corrugator and moderately lowered zygomatic activity during the fear segments. Corresponding to their happy facial imitations, subjects' self-reported joy and warmth were high and skin conductance was low. For anger, reported negative affect and GSR responses were high. When producing fearful faces, both positive and negative self-reported affect were moderately high, and the same was true of GSR. Heart rate dropped for all three facial patterns, but more so for the negative ones.

Winton et al (1984), using slides as stimuli, found that heart rate increased

linearly with pleasantness of subjective report and facial efference, while skin conductance increased with the intensity of facial efference and self-report, regardless of valence.

Finally, in a 1981 study, Schwartz and colleagues used the imagery technique to examine the blood pressure and heart rate correlates of happiness, sadness, anger, and fear in comparison to relaxed and control trials. Fear and happiness both were linked with increased heart rate and systolic blood pressure; but in fear, heart rate increased more. Sadness and happiness produced similar heart rate and systolic blood pressure levels, but sadness produced lower diastolic blood pressure. Anger, like fear, was associated with high heart rate and systolic blood pressure, but it produced higher diastolic blood pressure. Self-reported affect corresponded appropriately with each pattern of facial efference.

IMPLICATIONS FOR THE FEEDBACK HYPOTHESIS From the correlational literature it is clear that in between-subjects tests, facial expressiveness is negatively correlated with autonomic arousal. More crucial for the feedback hypothesis, however, are within-subjects comparisons. These show convincingly that increased facial expressiveness of emotion is correlated with increased physiological arousal, as the hypothesis predicts. Generally, it appears that facial efference of either positive or negative affect is associated with autonomic arousal, although there is some evidence that increased GSR is linked specifically to negative facial affect (Buck 1977; Buck et al 1972, 1974; Dimberg 1987a; Kleck et al 1976; McHugo et al 1985; Vaughan & Lanzetta 1980) and that increased heart rate is specific to pleasantness of the facial efference pattern (Brock et al 1986; McHugo et al 1985; Ridgeway & Waters 1987; Winton et al 1984), although the reverse has also been noted for heart rate (Buck et al 1972, 1974; Cohen et al 1986; Schwartz et al 1981).

As for subjective experience, specific affective self-reports increase almost without exception with facial efference patterns of the corresponding emotion. This is not surprising given that in most research paradigms the accompanying emotional stimulus could easily inform subjects of the appropriate feeling even if facial efference did not. But in studies where spontaneous facial efference was intensified without subject awareness (i.e. by using reinforcement, canned laughter, or the presence of an observer), self-reported affect increased correspondingly above the level reported to the emotional stimulus alone. These results suggest the possibility not only of a correspondence, but of a modulating influence of facial efference in the experience of emotion, a hypothesis explored more thoroughly in research using experimentally manipulated facial efference.

Experimental Studies of Facial Efference and Emotional Experience: the Modulating Function

The possibility that facial efference plays a causal role in emotion has long been a subject of theoretical speculation (Gratiolet 1865; Darwin 1896; James 1890, 1922). Although the original facial feedback hypotheses restrict consideration of this role to the context of ongoing, spontaneous emotion, research in which facial emotional action is experimentally manipulated has mushroomed in the past decade. Part of the reason is undoubtedly the inability of research using spontaneous efference to separate correlation from causality. Interest in the possibility of modulating, and, perhaps, initiating effects of facial efference is such that the term "facial feedback hypothesis" is now commonly defined in these terms (Buck 1980; Laird 1984; Matsumoto 1987).

Most work examining the role of voluntary facial efference focuses on its modulating function in emotional experience. Typically, an emotional stimulus (in the form of an external stimulus, such as a film, or an internal one, such as imagery) is introduced, and the effects on emotional experience of exaggerating or inhibiting a congruent facial efference pattern or simulating an incongruent pattern are examined.

PHYSIOLOGICAL EXPERIENCE In the literature relating facial efference to other components of emotional experience, correlational studies have focused largely on the physiological correlates while experimental studies have tended to focus on subjective experience. True to this split, only a few experimental studies on facial efference examine only physiological correlates.

In the first, Colby et al (1977) required subjects to facially pose high, moderate, and no pain on different shock trials. They found that as intensity of posed pain to a shock increased, so did subjects' GSR responses, but in the absence of shock, posed pain did not affect skin conductance. In the second study, a variant of their 1980 correlational study using spontaneous expressions, Vaughan & Lanzetta (1981) measured autonomic responses of subjects watching a model's display of pain in response to electric shock. The subjects were instructed either to inhibit their own facial patterns, to display pain when the model did so, or were given no instructions. The display group showed increased skin conductance and heart rate compared to the other two groups, which did not differ from each other.

Two recent studies used imagery to generate emotions. Ianni et al (1986) compared voluntary facial anger, disgust, neutral, and control conditions during anger imagery. Facial anger augmented cardiovascular activity compared to the other facial actions, particularly reducing finger blood flow; but skin conductance and heart rate were not significantly affected. Lanzetta, Kleck, and colleagues (Kappas et al 1987) reported that adding matching

overt facial action to self-generated emotions (happiness, sadness, anger, peacefulness) increased heart rate but did not change skin conductance.

SUBJECTIVE EXPERIENCE In contrast to the physiological data, a number of studies have focused on the effects of suppressing, exaggerating, or dissimulating facial efference on subjective experience during an emotional stimulus. One of the earliest was the Leventhal & Mace between-subjects experiment (1970) in which the evaluations of a comedy film by school children asked to smile and laugh as much as they could were compared with those of children asked not to laugh. Among girls, positive ratings of the film were higher in the exaggeration than the inhibition group, but the opposite was true for boys, although they laughed more.

Rhodewalt & Comer (1979) manipulated smiling, frowning, or neutral patterns using Laird's (1974) technique while subjects wrote a counterattitudinal essay. Subjects' mood was most positive in the smile and least positive in the frown conditions, with neutral in between. Mood was most negative in the frowning group, least negative in the smiling group, and in between for the neutral group. Attitude change was also greatest in the smiling and least in the frowning groups.

Laird and colleagues have made several within-subjects investigations of facial efference and mood. Laird (1974) first induced subjects to display smiles and angry frowns by manipulating muscle contraction patterns, and then exposed them to pictures of children and of the Ku Klux Klan. Aggression scores were higher on the frowning than smiling trials, and scores on elation and surgency scales were higher on smiling than frowning trials. (Anxiety, remorse, and social affection were not differentially affected by efference.) The difference between self-reported mood on smiling versus frowning trials was significantly larger for manipulated than for nonmanipulated observer subjects, suggesting an effect of efference above the effects of the slides. In a second experiment, subjects rated cartoons as funnier when in the smiling than in the frowning condition; elation was also higher (but not significantly) and aggression lower while smiling than when frowning. Laird & Crosby (1974) reported one successful and one unsuccessful replication of this work using humorous cartoons as stimuli.

Again using a technique similar to Lairds's, McArthur et al (1980) induced smiles, sad frowns, and neutral patterns while subjects viewed positive, negative, or neutral slides. Self-reported mood of normal-weight but not overweight subjects was less happy when frowning but not significantly happier when smiling compared to neutral across stimuli. In a replication reported in the same article the same pattern was found.

Rutledge & Hupka (1985) also used Laird's technique to pose joy and anger

in subjects viewing neutral slides and high and low anger and joy slides. In a within-subjects comparison, subjects reported feeling more joyous and less angry when posing joy, and more angry and less joyous when in an anger pose. The difference held across all stimulus intensities. The researchers also compared the self-reported affect of posed subjects with that of observers who had undergone the same experimental session but were instructed to keep facial muscles relaxed. The subjects when posing joy reported greater feelings of joy than their paired counterparts across stimuli, and when posing anger reported greater anger.

Kraut (1982) varied the experimental paradigm by using pleasant and unpleasant odors as affective stimuli in a within-subjects experiment. Posing a pleasant reaction increased the evaluated pleasantness of the odors while posing disgust decreased it compared to the ratings made while spontaneously reacting to the odors.

Three experiments have tested for modulating influences of facial efference during self-generated emotion. McCanne & Anderson (1987) asked subjects first to imagine a positive or negative situation, then to imagine the scene while enhancing either zygomatic or corrugator tension. In a third trial, they were instructed to suppress tension in that muscle during imagery. The muscle changes were verified by EMG but were otherwise not readily detectable. Suppressed zygomatic activity during positive affective scenes decreased self-reported enjoyment and increased distress; no other effects of muscle activity were significant. Klions and Dale (Riccelli et al 1984; Antila et al 1988) used self-referent statements to induce mood and posed facial actions monitored by EMG in two studies. In the first, positive and negative emotional facial actions (zygomatic and corrugator) increased self-reported elation and depression, respectively, compared to the reports of nonmanipulated subjects reading the statements. In the second, facial actions incongruent with the statements reduced the contrasting self-reported mood compared to reports of unmanipulated subjects, but the differences were not significant.

Rutledge and colleagues (1987) reported effects on felt emotion from isolated facial muscle contractions while viewing slides used in their earlier study. Across all slides, contraction of forehead muscles (occipitofrontalis) was associated with greater reported surprise; contraction of the corrugator (brow) was linked with feelings of anger. Triangularis contraction (pulling the mouth down) and zygomaticus contraction (creating a smile) were linked respectively with sadness and joy. This study was unusual in moving beyond a positive/negative (dimensional) distinction by linking specific forms of facial emotional efference with reported changes in discrete (categorical) emotions.

Strack and Martin (Strack et al 1988; L. L. Martin, T. F. Harlow, F. Strack, in preparation) have also tested dimensional versus categorical ef-

fects of facial efference using a technique requiring subjects to hold a pen in their mouths in different ways. In two initial experiments (Strack et al 1988), subjects held the pen either in their teeth (simulating a smile) or in their lips (simulating a frown). Their ratings of cartoon funniness were higher during the "smile" and lower during ther "frown" patterns compared to ratings in a control condition. Using the pen technique to simulate smiling, angry, and frowning efference (L. L. Martin, T. F. Harlow, F. Strack, in preparation), they first found evidence only for a dimensional perspective: "smiling" subjects reacted more positively to stories than did "frowning" or "angry"-faced subjects; but when stories were changed so that only angry (not sad) evaluations were appropriate, angry poses produced more angry evaluations but sad facial efference did not. The researchers also found that adding physiological arousal that could not readily be attributed to exercise increased negative and reduced positive ratings of stories for anger-posing subjects and produced the reverse effects for smile-posing subjects.

The data in this section are largely consistent in showing that voluntary facial efference, whether produced by direct request to express or inhibit or by more subtle muscle manipulation, changes subjective experience. Exaggeration of facial efference congruent with an emotional stimulus increases corresponding subjective experience of an emotion while inhibition reduces it. Simulating efference incongruent to a stimulus also reduces stimulus-consistent subjective experience. In the only study looking at more than two emotions, the results suggest that manipulation of emotion-specific efference increases the corresponding emotion-specific subjective experience.

PHYSIOLOGICAL AND SUBJECTIVE EXPERIENCE Two early studies dealt with the modulating effects of facial pose on subjective and physiological reactions to electric shock. In a between-subjects experiment by Kopel & Arkowitz (1974) subjects role-played either a calm or upset reaction or did not role-play during shock. Subjects posing an upset reaction reported feeling more pain and had a lower pain threshold than the neutral controls, while those posing calm reported less pain and a higher threshold. The calm facial pattern looked no different to observers than did the control, although the upset pattern did. Pulse rate was not affected by the role-playing. Lanzetta et al (1976) asked subjects to conceal or clearly reveal their reactions to shocks of varying intensity. Independent judges confirmed that facial displays for hiding and exaggerating trials differed in the appropriate directions from baseline patterns. Compared to the baseline (previously collected spontaneous reactions), hiding a facial response to shock reduced both GSR and the subjective report of shock painfulness; exaggerating the facial reaction increased both GSR and self-reported pain.

Subjects also suppressed or exaggerated the congruent patterns for

pleasant, unpleasant, and neutral film segments or reacted spontaneously in another study (Zuckerman et al 1981). Finger blood volume, skin conductance, and heart rate were measured, and subjects made self-reports. These researchers reported greatest autonomic arousal across stimuli in the exaggeration group, followed by the spontaneous expressers, and the lowest arousal among the suppressors. The differences were greater in groups viewing affect-laden films than in those viewing neutral films. Films were rated as more pleasant for pleasant scenes and more unpleasant for unpleasant scenes by the exaggerators than by the suppressors or spontaneous reactors, although the differences were not significant. Reported intensity of reactions was higher for the affective films when reactions were exaggerated. Higher levels of facial expressivity were associated with greater autonomic arousal and subjective experience within as well as between subjects.

In two studies, the effects of spontaneous reactions were compared to only one other posing condition. In the first, Ochsmann & Henrich (1984) found that female subjects (but not males) rated accident pictures as more frightening and showed increased physiological arousal when they exaggerated their reactions. (In men, self-reported frightfulness did not differ, and physiological response was lower when efference was amplified.) In the second, self-reports and autonomic responses corresponding with spontaneously occurring facial efference to pleasant, neutral, and unpleasant slides were compared to responses of subjects asked to display an incongruent pose (Putnam et al 1982). Self-reported pleasantness corresponded to pleasantness of facial efference in the unmanipulated condition, but decreased in the posed condition. Skin conductance was higher for affective than neutral slides among the spontaneous reactors, while heart rate accelerated more for pleasant than unpleasant slides. Posing incongruent efference increased skin conductance responses but not heart rate.

Tourangeau & Ellsworth (1979) compared the effects of congruent and incongruent posed faces, spontaneous efference, and nonemotional poses on self-reports and physiological responses to fearful, sad, and neutral stimulus films. When watching a neutral film, subjects posing fear reported higher subjective fear and subjects posing sadness reported greater sadness than did subjects in other face conditions, but the differences were not significant. For fearful and sad films, a congruent facial pose did not increase self-reports of the matching emotion above the levels reported by the unmanipulated and nonemotional-faced groups, and incongruent poses did not decrease self-reports of the filmed emotion. On the physiological measures, both fear-posing and sorrow-posing subjects showed greater drops in heart rate than did the nonemotional-faced group across all films, but less decrease than the spontaneous expressers. The spontaneous expressers showed the biggest GSR response, the fear-posing subjects the least.

IMPLICATIONS FOR THE MODULATING HYPOTHESIS Although the original facial feedback hypothesis would not have considered voluntarily modulated facial efference to be a theoretical equal to spontaneously produced efference (Tomkins 1962, 1981; Izard 1971, 1981), many researchers have nevertheless relied on manipulated efference in an attempt to clarify whether facial efference can play a modulating role in ongoing emotional experience. In general, in the subjective experience of emotion, it may; with only a few nonsignificant results (Laird & Crosby 1974; McCanne & Anderson 1987; Tourangeau & Ellsworth 1979) and one contradictory effect (Putnam et al 1982), the literature suggests that intensification of a congruent facial pattern enhances subjective experience, while an inhibited congruent pose or the pose of an incongruent emotion reduces subjective experience.

Exaggeration of facial efference generally increases GSR and inhibition reduces it, regardless of valence of efference. Only four attempts have addressed heart rate effects, with three revealing nondifferentiating increases for any efference pattern (Tourangeau & Ellsworth 1979; Vaughan & Lanzetta 1981; Zuckerman et al 1981) and one showing no significant change (Putnam et al 1982).

Experimental Studies of Facial Efference and Emotional Experience: the Initiating Function

A final and more difficult question to answer is whether facial efference can initiate emotional experience in the absence of an emotional stimulus. Some evidence relevant to this issue can be gleaned from conditions included in studies mentioned above, and in recent years a few attempts have been made to focus specifically on this question. In these studies, subjects are sometimes asked simply to pose a particular emotional face, are trained to contract particular muscles or combinations of muscles, or perform tasks that involve the facial muscles in ways approximating emotional postures.

PHYSIOLOGICAL AND SUBJECTIVE EXPERIENCE Evidence of the initiating potential of facial efference can be found in those studies mentioned above where one of the conditions involved posed efference during a neutral stimulus. (For these studies, unless otherwise noted, only trends can be ascertained because significance levels were not reported.)

Colby et al (1977) found no significant effects of posing pain facial patterns on GSR in the absence of actual shock. When presented with neutral pictures, subjects in McArthur et al's study (1980) reported slightly higher happiness when smiling than with a neutral face, and lower happiness when frowning. In the Rutledge & Hupka study (1985), in a neutral-stimulus condition, subjects posing joy reported slightly higher joy (but also slightly higher anger) than subjects with a neutral pose; when posing anger they reported more felt

anger and less felt joy than neutral posers. Fear posers reported more fear, and sadness posers more sadness, during a neutral film in the Tourangeau & Ellsworth study (1979), but the differences were not statistically significant. And, in response to a neutral slide in the Rutledge et al (1987) research, subjects contracting forehead muscles (resembling surprise) reported significantly more surprise than unposed subjects, and those posing joy (mouth up) and fear (mouth down) reported significantly more joy and fear, respectively, than unposed subjects.

Other studies have focused specifically on the potential initiating function of facial posture. McCaul et al (1982) asked subjects on different trials either to portray fear, to portray calm, or to show their usual face. In a first experiment, subjects showed higher pulse rates and skin conductance when they were portraying fear than for either the calm or normal expressions. Self-reported anxiety was not affected, a result that led the researchers to conclude that physiological changes were due to effort rather than change in emotion. To test this, in a second experiment they added trials in which happiness was portrayed. They also added noise as a situational manipulation of negative affect. Subjects rated the noise as less loud while portraying happiness (self-reported emotion was not directly assessed in this study). Pulse rate increased under both happiness and fear portrayals, but skin conductance did not change. The researchers believed the greater movement involved in these expressions as compared to calm or normal expressions accounted for pulse changes.

In two studies, Duncan & Laird manipulated facial posture to differentiate self-produced cue users from situational cue users for other purposes. In the context of a first study on self-attribution and attitude change (1977), they induced muscle poses of smiles, frowns, and neutral faces. Manipulated smiles corresponded to higher and frowns to lower elation and surgency than neutral (relaxed) efference in the presence of a neutral stimulus. A frowning face produced higher aggression scores than a neutral one, but smiling did not lower aggression compared to a neutral expression. In a later study on placebo effects (1980), the researchers successfully replicated this effect using slides of geometric forms as stimuli and using a group manipulation. Elation-surgency was significantly higher on smiling than frowning trials, and aggression was higher for frowning than for smiling trials; both smiles and frowns produced mood scores significantly different from those of a neutral facial pattern.

Four studies on biofeedback training as asthma treatment also fit within the consideration of facial efference and physiological consequences (Glaus & Kotses 1983; Harver & Kotses 1984; Kotses & Glaus 1981; Miller & Kotses 1987). This research involves relaxation or tensing of the frontalis muscle in the forehead, with dependent variables including respiratory expiration flow

rate, respiration rate, and heart rate. Relaxation of the frontalis muscle produced an increase in peak expiration flow rate and tension decreased flow rate; no changes in respiration rate or heart rate have been found. In comparison, forearm muscle tension or relaxation had no effect on any measure.

Ekman et al (1983) used facial poses of six different emotions and collected five physiological measures. Facial surprise, disgust, sadness, anger, fear, and happiness were manipulated using both directed facial action (a muscle contraction technique similar to those used by others) and relived emotion (resembling imagery techniques). In the posed efference condition, three subgroups of emotions were discriminated based on physiological measures: poses of happiness, disgust, and surprise were associated with low heart rate; fear and sadness were linked with high heart rate and low skin temperature; and anger was accompanied by high heart rate and high skin temperature. Forearm muscle tension did not vary. Of importance to the facial feedback hypothesis is the finding that autonomic changes were more clear-cut in the facial action condition than in the relived emotion (imagery) task.

Smith et al (1986) also used both posed and imagery-induced efference (happy, sad, angry, and neutral) and measured skin conductance and heart rate. As determined by EMG magnitudes, stronger efference patterns were produced by voluntarily posing, but the patterns were similar to the imagery-induced patterns. They split their sample into expressive and nonexpressive posers. The nonexpressives produced similar levels of facial activity when happiness was posed and when it was induced by imagery, but less activity when posing the negative emotions of sadness and anger compared to spontaneous efference. Skin conductance did not significantly differ by emotion when posed. Heart rate increased over the neutral condition for all three emotions; there was no difference in heart rate increase between expressives and nonexpressives, even though the latter showed less facial activity for negative emotions than did expressives.

In two recent studies, subjects performed tasks involving facial muscles in ways that approximate emotional facial efference patterns, and thereby allow the experimenter to examine the effects of facial efference alone, independently of its emotional content. Strack et al (1988) using the pen-holding technique, noted evidence of an effect of facial posture on self-reports even in the absence of their cartoon stimuli. And Zajonc and colleagues (R. B. Zajonc, S. Murphy, M. Inglehart, submitted), in the context of research on the vascular theory of emotional efference (Zajonc 1985), compared the subjective experience of subjects pronouncing or listening to various phonemes, some of which involve the action of muscles that are dominant in emotional expressions. For example, the production of the phoneme *e* resembles the smile. Photographers elicit smiles from their subjects by requiring them to say "cheese". The German phoneme *ü*, on the other hand, has just the

opposite action. Repeated pronunciation of *e* resulted in positive subjective reports as measured by ratings of liking, pleasantness, and preferences for the sound, whereas *ü* was judged unpleasant and was disliked, not only by American but by German subjects as well.

IMPLICATIONS FOR THE INITIATING FUNCTION The evidence in this section suggests that facial efference may play an emotion-specific initiating role as well as a modulating role in the subjective experience of emotion. Some significant results support this conclusion (Duncan & Laird 1977, 1980; Rutledge et al 1987; Strack et al 1988; R. B. Zajonc, S. Murphy, M. Inglehart, submitted), and trends apparent in the nonsignificant results are at least consistent with the hypothesis (McArthur et al 1980; Rutledge & Hupka 1985; Tourangeau & Ellsworth 1979; but not McCaul et al 1982).

As in most of the research on facial efference and physiological arousal, little autonomic differentiation by the particular form of efference has been apparent. Either no significant effects on arousal are produced by efference alone or it increases uniformly across different emotions (Colby et al 1977; Glaus & Kotses 1983; Smith et al 1986). The exceptions are the Ekman et al (1983) study, and the Zajonc-Murphy-Inglehart research. In the first, enough different physiological indexes were used to detect three differentiating patterns: one for happiness, disgust, and surprise, characterized by low heart rate; one for fear and sadness, with high heart rate and low skin temperature; and one for anger, with high heart rate and high skin temperature. In the second, temperature of the forehead showed clear distinction between positive and negative affect, cooling being associated with pleasant states and warming with unpleasant hedonic states. Thus, temperature—unlike GSR, heart rate, and similar autonomic indicators that do not discriminate hedonic polarity—offers a new, important, physiological index of emotion.

SUMMARY OF THE LITERATURE ON FACIAL FEEDBACK

We have divided our discussion of the literature of facial feedback into two classes: that which examines the correlates of facial efference under conditions that elicit it spontaneously, and that in which the modulating and initiating functions of facial efference can be examined through experimental manipulation.

In the correlational literature, we drew, as Buck (1980) did in his review, a distinction between within- and between-subjects tests of association between facial efference and emotional experience. We argued that the former are more pertinent to the original facial feedback hypothesis as variously pro-

posed by Tomkins (1962), Gellhorn, (1964), and Izard (1971), and that they generally support the hypothesis. Not only does intensity of facial efference correspond with greater subjective emotional experience in general, but particular facial efference patterns are positively correlated with subjective experience of the same emotions. Physiological arousal does not appear to vary differentially with the nature of the efference pattern but seems to increase with any increase in emotional efference.

More interest has been displayed recently in the modulating and initiating potentials of facial efference, explored through experimental manipulation of the face. The term "facial feedback hypothesis" has come to be defined by these functions, although the original proponents of the hypothesis disavow this usage (Tomkins 1981; Izard 1981). Although the experimental evidence is less unanimous than the correlational data, it appears to us that the literature supports these versions of the hypothesis, perhaps more convincingly for subjective experience than for physiological arousal.

It should be noted that in going from spontaneous efference to posing an emotion, contracting muscles in an emotion-like face, or performing other facial motor tasks, two things are likely to decrease simultaneously: the inferences subjects can consciously make about their feelings from the situation and from what their faces are doing, and the closeness of the facial efference to a spontaneous display. The first is an advantage in that it minimizes self-perception interpretations (Laird 1974) and has the strongest causal implications, while the second poses a clear disadvantage in attempting to generalize to naturally occurring facial emotional efference. Some evidence suggests that voluntarily posed efference patterns and spontaneous ones are innervated through different pathways (Monrad-Krohn 1924, 1939). However, compared to spontaneous efference, posed faces tend to be quite similar both in appearance (Borod et al 1986a, b) and EMG patterns for each emotion (Schwartz et al 1979) and thus, perhaps, in their feedback patterns to the brain. One of the main differences between spontaneous and posed efference seems to be the greater asymmetry of the latter (Ekman et al 1981).

To the extent that voluntarily produced efference can be assumed to adequately correspond to spontaneous emotional efference, the experimental evidence suggests that facial efference may play an important causal role in the subjective experience of emotion. In this, other reviewers at least partially agree. Laird (1984) concluded that these experimental studies "have demonstrated effects of varying the magnitude of expressive behavior on both self-reports of emotional experience and on various measures of physiological arousal such as heart rate and skin conductance" (p. 910). Winton (1986) agreed that the literature supports the modern facial feedback hypothesis, but cautioned that it only supports a "dimensional" view, in that almost all studies compare only one positive to one negative emotion. The exception at that time

was the Tourangeau & Ellsworth study (1979), which in comparing the two negatively valenced emotions of fear and sadness failed to support a "categorical" feedback hypothesis; their study was criticized, however, on both theoretical and methodological grounds (Hager & Ekman 1981; Izard 1981; Tomkins 1981). The more recent studies by Rutledge et al (1988) and Strack et al (1988) do support a categorical version, but more studies in this vein are clearly called for. Finally, Matsumoto (1987) moved beyond a conventional review by submitting the studies reviewed by Laird (1984) to meta-analysis, and concluded that "the meta-analytic procedures indicate that the effect of facial manipulation on self-reported emotional experience is of moderate value" (p. 772).

CONTEMPORARY THEORETICAL ISSUES IN FACIAL FEEDBACK: WHAT IS FED BACK?

The empirical literature bearing on the facial feedback hypothesis strongly suggests that facial emotional efference is not only correlated with emotional experience but may modulate and initiate it. The evidence on the physiological component of that experience is weaker. If facial efference plays a causal role in the subjective experience of emotion, as the empirical literature suggests it does, it is likely to do so directly rather than by first initiating physiological arousal that is then subjectively experienced as emotion. Perhaps the most interesting contemporary theoretical question in this domain, therefore, is how fácial efference may play a causal role in the subjective experience of emotion.

In general, theory has lain dormant on this question since the original facial feedback hypotheses, in which muscular proprioceptive patterns (Gellhorn 1964; Izard 1971; Tomkins 1962) and cutaneous sensation (Gellhorn 1964; Tomkins 1980) were proposed as mechanisms. Ekman (1984) has suggested that motor cortex directing facial muscle activity simultaneously connects with hypothalamic areas to stimulate ANS activity, but his model does not directly address subjective experience. Laird (1974, 1984), drawing on self-perception as a possible mechanism, does specifically focus on subjective experience; but the most recent facial feedback studies using mechanical manipulations of the face now make his position less tenable.

One exception to the current dearth of theoretical progress on facial efference in the experience of emotion is a recently reclaimed theory (Zajonc 1985) that links emotional efference to vascular processes. The author of the vascular theory of emotional efference (VTEE), Israel Waynbaum (1907), argued that facial movements in general, and emotional efference in particular, have regulatory and restorative functions for the vascular system of the head. He noted the intimate relationship between facial and cerebral blood

flow (CBF), and suggested that facial muscular movements contribute to the regulation of CBF by pressing against facial veins and arteries and thus shunting blood to the brain when needed or diverting it away when the brain is threatened with excess. The face, according to Waynbaum, acts as a safety valve for the brain, where blood supply can vary only within very narrow limits. He also suggested that these regulatory muscular actions of the face have subjective consequences: Changes in CBF caused by facial motor movement are reflected as changes in feeling states. He did not disagree with Darwin (1896) that the function of emotional facial gestures is to communicate the individual's internal states to others, but he held that the communicative function was secondary.

Several of Waynbaum's assumptions are questionable and others are wrong (Burdett 1985; Fridlund & Gilbert 1985; Izard 1985; Zajonc 1986). For instance, arterial flow is unlikely to be much affected by muscular action of the face. Furthermore, arterial blood flow is under the control of so many other central factors that peripheral action could only have negligible direct effects. Facial muscles, however, can affect venous flow. Regardless of the particular physiological processes that may be involved, it is both plausible and theoretically important that facial efferents may have direct regulatory functions and subjective consequences. If true, VTEE organizes diverse findings such as biofeedback, placebo effects, unconscious preferences and aversions, growth of preference with repeated exposure, empathy, etc (Zajonc 1986). The particular neurophysiological and neurochemical processes are yet to be specified by empirical investigations. Useful speculations about such processes that would guide future research, however, can be made.

A testable hypothesis that follows from VTEE is that facial efferents can produce changes in brain blood temperature which, in turn, can facilitate and inhibit the release and synthesis of a variety of neurotransmitters. Thus, if a certain facial muscle action changes the temperature in a brain region where serotonin is released, for example, then the resulting serotonin regulation might cause the individual to experience joyful or depressive affect. Not all neurochemicals that have subjective effects are region specific. Peptides, for example, are found in profusion throughout the entire brain, and a change in temperature might change the threshold of the enzymatic actions that release them. R. B. Zajonc, Sheila Murphy, and Marita Inglehart (submitted) observed systematic correlations between changes in temperature and hedonic tone as simultaneous reactions to uttering various phonemes. They explained the results by assuming that the production of various phonemes may facilitate or impair the air cooling of the venous blood that enters the cavernous sinus. The latter is a venous structure that cools arterial blood as it enters the brain. In an experiment which subjects thought involved the psychophysics of olfaction, cool (19° C) and warm (32° C) air was introduced into subjects'

nostrils and ratings of the odors were collected. On some trials no odor was present, yet subjects rated cool air as decidedly pleasant and warm air as decidedly unpleasant. To be sure, the conjecture that brain temperature changes can influence the release and synthesis of neurohormones and neuroenzymes associated with subjective emotional states still needs empirical documentation.

CONCLUSIONS

1. There are no sufficient grounds thus far to reject *any* theory of the role of facial efference in the experience of emotion. The neglected early theories based on the sensory process have a great deal to offer given that emotional experience depends heavily on sensory input and its derivatives; the neuroanatomical connections and processes indicate a powerful role of the sensory process in emotion (LeDoux 1987). Hence, the work of Piderit and Gratiolet deserves greater attention in contemporary research. In addition, there is no conflict among the sensory theories of emotional efference, Darwin's evolutionary perspective on efference, and the facial feedback hypotheses. Clearly, nothing prevents a facial emotional action from depending on a peripheral process that is allied to sensation, having adaptive communicative value, and also arousing in the actor the subjective experience of emotion.

2. The correlational evidence reviewed here clearly indicates a positive association between facial efference and emotional experience within subjects, particularly for the subjective component of emotion, in support of the facial feedback hypothesis. Intensity of facial efference of a specific emotion corresponds with increasing subjective experience of the same emotion.

3. Although the experimental evidence on facial feedback is less conclusive than the correlational literature, it tends to support the notion that facial efference plays not only a modulating function but an initiating function in the experience of emotion, particularly for subjective experience. Some initial evidence suggests that facial efference may causally differentiate not only positive from negative subjective experience, but may produce emotion-specific effects. More research comparing facial efference patterns for two or more emotions of the same valence is needed.

4. The facial feedback hypothesis does not explain why some facial actions "feel" good and others "feel" unpleasant. There is some promise in this respect from the vascular theory of emotional efference, which attributes changes in subjective hedonic states to changes in neurochemistry of the brain caused by changes in temperature reaching the hypothalamus via the cavernous sinus. If facial action can influence the thermoregulatory action of the cavernous sinus it might thereby influence the release and synthesis of some peptides and neurotransmitters that are highly temperature dependent

and have been found to produce hedonic changes. The most significant finding here is that for the first time a physiological indicator, forehead temperature, has been found to discriminate reliably between positive and negative affect.

5. The mounting evidence that facial efference under some conditions may modulate or even initiate subjective emotional experience suggests that a theoretical position that clings to the term "expression" misrepresents the complex and varied roles of the face in the experience of emotion.

Literature Cited

Allport, F. H. 1924. *Social Psychology*. Chicago: Houghton Mifflin

Angell, J. R. 1916. A reconsideration of James' theory of emotion in the light of recent criticisms. *Psychol. Rev.* 23:251–61

Antila, C. E., Dale, J. A., Klions, H. L. 1988. *Depressive and elative mood induction as a function of antagonistic facial expressions*. Presented at Ann. Meet. Eastern Psychol. Assoc., Buffalo, NY

Block, J. 1957. A study of affective responsiveness in a lie detection situation. *J. Abnorm. Soc. Psychol.* 55:11–15

Borod, J. C., Koff, E., Buck, R. 1986a. The neuropsychology of facial expression: data from normal and brain-damaged adults. In *Nonverbal Communication in the Clinical Context*, ed. R. Blanck, R. Buck, N. Rosenthal, pp. 196–222. University Park, PA: Penn. State Univ. Press

Borod, J. C., Koff, E., Lorch, M. P., Nicholas, M. 1986b. The expression and perception of facial emotion in brain-damaged patients. *Neuropsychologia* 24:169–80

Brock, S. E., Rothbart, M. K., Derryberry, D. 1986. Heart-rate deceleration and smiling in 3-month-old infants. *Infant Behav. Dev.* 9:403–14

Brown, S., Schwartz, G. E. 1980. Relationships between facial electromyography and subjective experience during affective imagery. *Biol. Psychol.* 11:49–62

Buck, R. 1977. Nonverbal communication of affect in preschool children: relationships with personality and skin conductance. *J. Pers. Soc. Psychol.* 35:225–36

Buck, R. 1980. Nonverbal behavior and the theory of emotion: the facial feedback hypothesis. *J. Pers. Soc. Psychol.* 38:811–24

Buck, R., Miller, R. E., Caul, W. F. 1974. Sex, personality, and physiological variables in the communication of affect via facial expression. *J. Pers. Soc. Psychol.* 30:587–96

Buck, R., Savin, V., Miller, R., Caul, W. 1972. Communication of affect through facial expressions in humans. *J. Pers. Soc. Psychol.* 23:362–71

Bull, N. 1951. The attitude theory of emotion. *J. Nerv. Mental Dis. Monogr.* 81. New York

Burdett, A. 1985. Emotion and facial expression. *Science* 230:608

Cacioppo, J. T., Petty, R. E., Losch, M. E., Kim, H. S. 1986. Electromyographic activity over facial muscle regions can differentiate the valence and intensity of affective reactions. *J. Pers. Soc. Psychol.* 50:260–68

Cannon, W. B. 1915. *Bodily Changes in Pain, Hunger, Fear, and Rage*. New York: Appleton

Cannon, W. B. 1927. The James-Lange theory of emotions: a critical examination and an alternative theory. *Am. J. Psychol.* 39:106–12

Cannon, W. B. 1931. Again the James-Lange and the thalamic theories of emotion. *Psychol. Rev.* 38:281–95

Cohen, B., Izard, C. E., Simons, R. F. 1986. Facial and physiological indices of emotions in mother-infant interactions. *Psychophysiology* 23: 429 (Abstr.)

Colby, C., Lanzetta, J., Kleck, R. 1977. Effects of the expression of pain on autonomic and pain tolerance responses to subject-controlled pain. *Psychophysiology* 14: 537–40

Cupchik, G. C., Leventhal, H. 1974. Consistency between expressive behavior and the evaluation of humorous stimuli: the role of sex and self-observation. *J. Pers. Soc. Psychol.* 30:429–42

Darwin, C. R. 1896. *The Expression of Emotions in Man and Animals*. New York: Appleton

Dimberg, U. 1982. Facial reactions to facial expressions. *Psychophysiology* 19:643–47

Dimberg, U. 1987a. Facial reactions and autonomic activity to auditory stimuli with high and low intensity. *Psychophysiology* 24:586 (Abstr.)

Dimberg, U. 1987b. Facial reactions and ex-

perienced emotion to visual emotional stimuli. *Psychophysiology* 24:586 (Abstr.)
Duncan, J., Laird, J. D. 1977. Cross-modality consistencies in individual differences in self-attribution. *J. Pers.* 45:191–206
Duncan, J., Laird, J. D. 1980. Positive and reverse placebo effects as a function of differences in cues used in self-perception. *J. Pers. Soc. Psychol.* 39:1024–36
Ekman, P. 1984. Expression and the nature of emotion. In *Approaches to Emotion*, ed. K. R. Scherer, P. Ekman, pp. 319–43. Hillsdale, NJ: Erlbaum
Ekman, P., Friesen, W. V., Ancoli, S. 1980. Facial signs of emotional experience. *J. Pers. Soc. Psychol.* 39:1125–34
Ekman, P., Hager, J., Friesen, W. 1981. The symmetry of emotional and deliberate facial actions. *Psychophysiology* 18:101–6
Ekman, P., Levenson, R. W., Friesen, W. V. 1983. Autonomic nervous system activity distinguishes among emotions. *Science* 221:1208–10
Fridlund, A. J., Gilbert, A. N. 1985. Emotion and facial expression. *Science* 230:607–8
Gellhorn, E. 1964. Motion and emotion: the role of proprioception in the physiology and pathology of the emotions. *Psychol. Rev.* 71:457–72
Glaus, K., Kotses, H. 1983. Facial muscle tension influences lung airway resistance; limb muscle tension does not. *Biol. Psychol.* 17:105–20
Gratiolet, P. 1865. *De la physionomie et des mouvements d'expression*. Paris: Hetzel
Hager, J. C., Ekman, P. 1981. Methodological problems in Tourangeau and Ellsworth's study of facial expression and experience of emotion. *J. Pers. Soc. Psychol.*, 40:358–62
Harver, A., Kotses, H. 1984. Pulmonary changes induced by frontal EMG training. *Biol. Psychol.* 18:3–10
Ianni, P., Stettner, L., Freedman, R. R. 1986. Voluntary facial actions modulate cardiovascular responses during angry emotion. *Psychophysiology* 23:443 (Abstr.)
Izard, C. E. 1971. *The Face of Emotion*. New York: Appleton-Century-Crofts
Izard, C. E. 1981. Differential emotions theory and the facial feedback hypothesis of emotion activation: comments on Tourangeau and Ellsworth's "The role of facial response in the experience of emotion." *J. Pers. Soc. Psychol.* 40:350–54
Izard, C. E. 1985. Emotion and facial expression. *Science* 230:608
James, W. 1890. *The Principles of Psychology*. New York: Holt
James, W. 1922. What is an emotion? In *The Emotions*, ed. K. Dunlap, pp. 11–30. Baltimore, MD: Williams & Wilkins Co. (original work published 1884)
Jones, H. E. 1935. The galvanic skin reflex as related to overt emotional expression. *Am. J. Psychol.* 47:241–51
Jones, H. E. 1948. The study of patterns of emotional expression. In *Feelings and Emotions: The Mooseheart Symposium*, ed. M. L. Reymert, pp. 161–68. New York: McGraw-Hill
Kappas, A., Hess, U., McHugo, G. J., Lanzetta, J. T., Kleck, R. E. 1987. The facilitative effects of facial expression on self-generated emotion. *Psychophysiology* 24:595 (Abstr.)
Kleck, R. E., Vaughan, R. C., Cartwright-Smith, J., Vaughan, K. B., Colby, C. Z., et al. 1976. Effects of being observed on expressive subjective, and physiological responses to painful stimuli. *J. Pers. Soc. Psychol.* 34:1211–18
Kleinke, C. L., Walton, J. H. 1982. Influence of reinforced smiling on affective responses in an interview. *J. Pers. Soc. Psychol.* 42:557–65
Kopel, S., Arkowitz, H. 1974. Role playing as a source of self-observation and behavior change. *J. Pers. Soc. Psychol.* 29:677–86
Kotses, H., Glaus, K. D. 1981. Applications of biofeedback to the treatment of asthma: a critical review. *Biofeedback Self-Reg.* 6: 573–93
Kraut, R. E. 1982. Social presence, facial feedback, and emotion. *J. Pers. Soc. Psychol.* 42:853–63
Laird, J. D. 1974. Self-attribution of emotion: the effects of expressive behavior on the quality of emotional experience. *J. Pers. Soc. Psychol.* 29:475–86
Laird, J. 1984. The real role of facial response in the experience of emotion: a reply to Tourangeau and Ellsworth, and others. *J. Pers. Soc. Psychol.* 47:909–17
Laird, J., Crosby, M. 1974. Individual differences in self-attribution of emotion. In *Thinking and Feeling: The Cognitive Alteration of Feeling States*, ed. H. London, R. Nisbett, pp. 44–59. Chicago: Aldine
Landis, C. 1932. An attempt to measure emotional traits in juvenile delinquency. In *Studies in the Dynamics of Behavior*, ed. K. S. Lashley, pp. 265–323. Chicago: Univ. Chicago Press
Lanzetta, J. T., Cartwright-Smith, J., Kleck, R. E. 1976. Effects of nonverbal dissimulation on emotional experience and autonomic arousal. *J. Pers. Soc. Psychol.* 33:354–70
Lanzetta, J., Kleck, R. 1970. Encoding and decoding of nonverbal affect in humans. *J. Pers. Soc. Psychol.* 16:12–19
Learmonth, G., Ackerly, W., Kaplan, M. 1959. Relationships between palmar skin potential during stress and personality variables. *Psychosom. Med.* 21:150–57
LeDoux, J. E. 1987. Emotion. In *Handbook of*

Physiology—The Nervous System V, ed. F. Plum, pp. 419–59. Washington, DC: Am. Physiol. Soc.
Levenson, R. W. 1989. Emotion and the autonomic nervous system: a prospectus for research on autonomic specificity. In *Social Psychophysiology: Theory and Clinical Applications*, ed. H. Wagner. London: Wiley. In press
Leventhal, H., Cupchik, G. C. 1975. The informational and facilitative effects of an audience upon expression and the evaluation of humorous stimuli. *J. Exp. Soc. Psychol.* 11:363–80
Leventhal, H., Mace, W. 1970. The effect of laughter on evaluation of a slapstick movie. *J. Pers.* 38:16–30
McArthur, L. Z., Solomon, M. R., Jaffe, R. H. 1980. Weight differences in emotional responsiveness to proprioceptive and pictorial stimuli. *J. Pers. Soc. Psychol.* 39:308–19
McCanne, T. R., Anderson, J. A. 1987. Emotional responding following experimental manipulation of facial electromyographic activity. *J. Pers. Soc. Psychol.* 52:759–68
McCaul, K. D., Holmes, D. S., Solomon, S. 1982. Voluntary expressive changes and emotion. *J. Pers. Soc. Psychol.* 42:145–52
McHugo, G. J. 1983. *Facial EMG and self-reported emotion*. Presented at Ann. Meet. Soc. Psychophysiol. Res., 23rd, Asimilomar, CA
McHugo, G. J., Lanzetta, J. T., Sullivan, D. G., Masters, R. D., Englis, B. G. 1985. Emotional reactions to a political leader's expressive displays. *J. Pers. Soc. Psychol.* 49:1513–29
Matsumoto, D. 1987. The role of facial response in the experience of emotion: more methodological problems and a meta-analysis. *J. Pers. Soc. Psychol.* 52:769–74
Miller, D. J., Kotses, H. 1987. The effects of facial muscle tension changes upon total respiratory resistance determined by the forced oscillations technique. *Psychophysiology* 24:601 (Abstr.)
Monrad-Krohn, G. H. 1924. On the dissociation of voluntary and emotional innervation in facial paresis of central origin. *Brain* 47:22–35
Monrad-Krohn, G. H. 1939. On facial dissociation. *Acta Psychiatr. Neurol. Scand.* 14:557–66
Notarius, C. I., Wemple, C., Ingraham, L. J., Burns, T. J., Kollar, E. 1982. Multichannel responses to an interpersonal stressor: interrelationships among facial display, heart rate, self-report of emotion, and threat appraisal. *J. Pers. Soc. Psychol.* 43:400–8
Notarius, C., Levenson, R. 1979. Expressive tendencies and physiological response to stress. *J. Pers. Soc. Psychol.* 37:1204–10
Ochsmann, R., Henrich, R. 1984. Erregungsniveau, expressives Verhalten und die Bemertung aversives Stimulation. (Physiological arousal, expressive behavior). *Z. Exp. Angew. Psychol.* 31:287–307
Pasquarelli, B., Bull, N. 1951. Experimental investigation of the body-mind continuum in affective states. *J. Nerv. Ment. Dis.* 113:512–21
Perry, R. B. 1926. *General Theory of Value: Its Meaning and Basic Principles Contrasted in Terms of Interest*. New York: Longmans, Green
Piderit, T. 1858. *Grundzüge der Mimik und Physiognomik*. Braunschweig: Vieweg und Sohn
Piderit, T. 1888. *La Mimique et la physiognomie*. Paris: Alcan
Prideaux, E. 1920. The psychogalvanic reflex: a review. *Brain* 43:50–73
Putnam, L., Winton, W., Krauss, R. 1982. Effects of nonverbal affective dissimulation on phasic autonomic and facial responses. *Psychophysiology* 19:580–81
Rhodewalt, F., Comer, R. 1979. Induced compliance attitude change: once more with feeling. *J. Exp. Soc. Psychol.* 15:35–47
Riccelli, P., Klions, H., Dale, A. 1984. Induced depression and elation enhanced by experimenter-demanded facial expression: physiological measures. *Psychophysiology* 21: 594 (Abstr.)
Ridgeway, D., Waters, E. 1987. Induced mood and preschoolers' behavior: Isolating the effects of hedonic tone and degree of arousal. *J. Pers. Soc. Psychol.* 52:620–25
Rutledge, L. L., Hupka, R. B. 1985. The facial feedback hypothesis: methodological concerns and new supporting evidence. *Motiv. Emotion* 9:219–40
Rutledge, L. L., Garvey, J., Johnson, C., Sheldon, B. 1987. *Interaction of facial muscle contractions, subjective emotion, and emotion context*. Presented at Ann. Conv. Am. Psychol. Assoc., 98th, New York
Schwartz, G. E., Ahern, G. L., Brown, S. 1979. Lateralized facial muscle responses to positive and negative emotional stimuli. *Psychophysiology* 16:561–71
Schwartz, G. E., Brown, S., Ahern, G. L. 1980. Facial muscle patterning and subjective experience during affective imagery: sex differences. *Psychophysiology* 17:75–82
Schwartz, G. E., Fair, P. L., Salt, P., Mandel, M. R., Klerman, G. L. 1976. Facial muscle patterning to affective imagery in depressed and nondepressed subjects. *Science* 192:489–91
Schwartz, G. E., Weinberger, D. A., Singer, J. A. 1981. Cardiovascular differentiation of happiness, sadness, anger, and fear

following imagery and exercise. *Psychosom. Med.* 43:343–64
Sherrington, C. S. 1900. Experiments on the value of vascular and visceral factors for the genesis of emotion. *Proc. R. Soc. London* 56:390–403
Sirota, A. D., Schwartz, G. E., Kristeller, J. L. 1987. Facial muscle activity during induced mood states: differential growth and carryover of elated versus depressed patterns. *Psychophysiology* 24:691–99
Smith, C. A., McHugo, G. J., Lanzetta, J. T. 1986. The facial muscle patterning of posed and imagery-induced expressions of emotion by expressive and nonexpressive posers. *Motiv. Emotion* 10:133–57
Strack, F., Martin, L. L., Stepper, S. 1988. Inhibiting and facilitating conditions of facial expressions: a non-obtrusive test of the facial feedback hypothesis. *J. Pers. Soc. Psychol.* 54:768–77
Sutherland, M. E., Rasayon, K. B., Harrell, J. P., Neita, D., Fields, C. 1984. Physiological and affective responses to emotional imagery in a black population. *Psychophysiology* 21:596
Teasdale, J., Bancroft, J. 1977. Manipulation of thought content as a determinant of mood and corrugator EMG activity in depressed patients. *J. Abnorm. Psychol.* 86:235–41
Tomkins, S. S. 1962. *Affect, Imagery, Consciousness:* Vol. 1. *The Positive Affects.* New York: Springer
Tomkins, S. S. 1963. *Affect, Imagery, Consciousness:* Vol. 2. *The Negative Affects.* New York: Springer
Tomkins, S. S. 1980. Affect as amplification: some modifications in theory. In *Emotion: Theory, Research and Experience,* ed. R. Plutchik, H. Kellerman, pp. 141–64. New York: Academic
Tomkins, S. S. 1981. The role of facial response in the experience of emotion: a reply to Tourangeau and Ellsworth. *J. Pers. Soc. Psychol.* 40:355–57
Tourangeau, R., Ellsworth, P. C. 1979. The role of facial response in the experience of emotion. *J. Pers. Soc. Psychol.* 37:1519–31
Vaughan, K., Lanzetta, J. 1980. Vicarious instigation and conditioning of facial expressive and autonomic responses to a model's expressive display of pain. *J. Pers. Soc. Psychol.* 38:909–23
Vaughan, K., Lanzetta, J. 1981. The effect of modification of expressive displays on vicarious emotional arousal. *J. Exp. Soc. Psychol.* 17:16–30
Waynbaum, I. 1907. *La Physionomie Humaine: Son Mécanisme et son Rôle Social.* Paris: Alcan
Winton, W. 1986. The role of facial response in self-reports of emotion: a critique of Laird. *J. Pers. Soc. Psychol.* 50:808–12
Winton, W. M., Putnam, L. E., Krauss, R. M. 1984. Facial and autonomic manifestations of the dimensional structure of emotion. *J. Exp. Soc. Psychol.* 20:195–216
Zajonc, R. B. 1985. Emotion and facial efference: a theory reclaimed. *Science* 228:15–21
Zajonc, R. B. 1986. *The face as a primary instrument of social process.* Presented at Symp. "Social Psychology and the Emotions," Maison des Sciences de l'Homme, Paris
Zuckerman, M. K., Corman, R., Larrance, D. T., Spiegel, N. H. 1981. Facial, autonomic, and subjective components of emotion: the facial feedback hypothesis versus the externalizer-internalizer distinction. *J. Pers. Soc. Psychol.* 41:929–44