

Electromyographic Activity Over Facial Muscle Regions Can Differentiate the Valence and Intensity of Affective Reactions

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Physiological measures have traditionally been viewed in social psychology as useful only in assessing general arousal and therefore as incapable of distinguishing between positive and negative affective states. This view is challenged in the present report. Sixteen subjects in a pilot study were exposed briefly to slides and tones that were mildly to moderately evocative of positive and negative affect. Facial electromyographic (EMG) activity differentiated both the valence and intensity of the affective reaction. Moreover, independent judges were unable to determine from viewing videotapes of the subjects' facial displays whether a positive or negative stimulus had been presented or whether a mildly or moderately intense stimulus had been presented. In the full experiment, 28 subjects briefly viewed slides of scenes that were mildly to moderately evocative of positive and negative affect. Again, EMG activity over the brow (corrugator supercilia), eye (orbicularis oculi), and cheek (zygomatic major) muscle regions differentiated the pleasantness and intensity of individuals' affective reactions to the visual stimuli even though visual inspection of the videotapes again indicated that expressions of emotion were not apparent. These results suggest that gradients of EMG activity over the muscles of facial expression can provide objective and continuous probes of affective processes that are too subtle or fleeting to evoke expressions observable under normal conditions of social interaction.

In focusing on the powerful situational factors governing behavior, social psychologists have sometimes ignored or dismissed physiological factors and measures as being irrelevant, at least at present, to the study of social processes and behavior. When physiological principles or measures have been used, the analyses have oftentimes been untestable (Wilson, 1975) or crude and accompanied by the disclaimer that they reflected the "state of the art in social psychology" (cf. Kiesler & Pallak, 1976, p. 1015). The primary physiological construct to have had a major impact on social psychological research and theory during the past half century is the notion of general, diffuse, and misattributable arousal (cf. Lindzey & Aronson, 1985). Yet the notion of arousal has its limits. In reviewing past literature on physiological arousal, Fowles (1980) noted that

The effect of attempting to assimilate all of these traditions to a single arousal theory was to create a model in which the reticular activating system was assumed to serve as a generalized arousal mechanism which responded to sensory input of all kinds, energized behavior, and produced both EEG and sympathetic nervous system activation . . . As is well-known, this model failed the empirical test rather badly. (p. 88)

For years the notion of general arousal, which has been based largely on single physiological measures (e.g., Breckler, 1984), analyses of tonic changes in somatovisceral activity (e.g., Elkin & Leippe, 1985), performance on "drive sensitive tasks" (Pallak & Pittman, 1972), or simple self-reports or misattributions of bodily sensations (e.g., Higgins, Rhodewalt, & Zanna, 1979), has overshadowed the theoretically compatible notion that subtle changes in efference, particularly within the facial muscles, are exquisitely sensitive to variations in intrapersonal (e.g., transient affective reactions) and interpersonal (e.g., veridical and deceptive communications among individuals) processes. For instance, physiological measures have traditionally been viewed in social psychology as useful only in assessing general arousal and therefore as incapable of distinguishing between positive and negative affective states (e.g., Fishbein & Ajzen, 1975, p. 94; Schachter, 1964)—despite long-standing suggestions to the contrary:

The low visibility of the affects and the difficulties to be encountered in attempting to identify the primary affects have already been described. Yet our task is not as difficult as it might otherwise have been, for the primary affects, before the transformations due to learning, seem to be innately related in a one-to-one fashion with an organ system which is extraordinarily visible. (Tomkins, 1962, p. 204)

Tomkins was of course referring to the facial efference system—an organ system we know from common experience is

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experimental stimulus was preceded and followed by a 0.5-s presentation of a neutral polygon. Subjects were told that the polygons were presented as focal points to ensure that subjects could avoid moving and focus on the screen throughout the presentation of the pictorial scene. Each subject was exposed to 20 pleasant and 20 unpleasant stimuli during the session. Surface EMG activity was measured over the corrugator supercilia (brow), zygomatic major (cheek), orbicularis oculi (lower eyelid), medial frontalis (forehead), orbicularis oris (lip), and superficial forearm flexor muscle regions during trials, and after each trial subjects responded to several questions about the depicted scene, including how much they liked it. Skin conductance was also monitored to examine the effects of the mildly evocative stimuli on sympathetic activity. Finally, subjects' faces were videotaped unobtrusively throughout the session, and periods during which subjects were exposed to the positive and negative stimuli were identified.

As expected, subjects reported liking the pleasant stimuli more than the unpleasant stimuli, $F(1, 14) = 480.69, p < .01$. Each subject's set of ratings was used to distinguish between the scenes that were mildly versus moderately liked and between the scenes that were mildly versus moderately disliked, and 2 (valence: positive or negative) \times 2 (intensity: mild or moderate) analyses of variance (ANOVAs) were performed to examine the separable effects of affective valence and affective intensity on physiological responding. The ANOVAs of the mean amplitude of the EMG activity over the corrugator supercilia and zygomatic major muscle regions produced the expected main effects for valence: $F(1, 14) = 21.47, p < .01$, and $F(1, 14) = 5.02, p < .05$, respectively. There was also a Valence \times Intensity interaction on the measure of EMG activity over the corrugator supercilia region, $F(1, 14) = 9.03, p < .01$. Briefly, the facial efferece to the brow region decreased as the subjects' affective reaction to the compound stimulus became more positive, whereas the efferece to the cheek region was simply higher during positive than negative stimulus presentations. Analyses also revealed several unexpected effects. Positive stimulus presentations evoked higher EMG activity over the orbicularis oculi region, $F(1, 14) = 6.46, p < .05$, and lower EMG activity over the medial frontalis muscle region, $F(1, 14) = 9.40, p < .05$, than did negative stimulus presentations. In addition, a Valence \times Intensity interaction on the measure of EMG activity over the medial frontalis region, $F(1, 14) = 5.15, p < .05$, reflected equivalent levels of activity in response to mildly positive and negative stimuli but higher levels of EMG activity in response to moderately negative than to moderately positive stimuli. Also, a Valence \times Intensity interaction on the forearm flexor muscle region, $F(1, 14) = 6.54, p < .05$, reflected the fact that EMG activity was highest during mildly negative stimulus presentations and lowest during mildly positive stimulus presentations.²

Despite the general nature of the somatic activity associated with the experimental stimuli, these pilot data are consistent with the notion that facial EMG activity varies as a function of both the intensity and valence of people's affective reactions. Indeed, analyses of skin conductance responding (frequency and amplitude) revealed no significant effects or interactions, which suggests that the experimental stimuli were sufficiently mild to prevent the evoking of sympathetic activation.

These data, of course, do not address whether the facial actions evoked by the experimental stimuli were sufficiently incipient to

be indistinguishable visually in social contexts. To examine this question, eight independent judges attempted to determine the emotional valence and the intensity of the experimental stimulus shown to subjects. Each judge was seated approximately .75 m directly in front of a 48.26-cm (19-in.) color monitor and viewed a random sample of 160 videotape excerpts of subjects' faces during 80 positive and 80 negative experimental trials. After the presentation of each excerpt, judges indicated whether their impression from viewing the subject's face led them to believe the excerpt was from a positive or negative trial and whether the stimulus had been classified as mildly or moderately intense by the subject. Analyses revealed that each of the eight judges performed at chance level. In addition, judges indicated that they perceived so few changes in subjects' facial appearances that they too viewed the majority of their ratings as mere guesses. Hence, the EMG responses to the experimental stimuli reflected affective processes that were not apparent in overt facial expressions—at least under normal viewing conditions.

We conducted a conceptual replication of the pilot study using simpler affective stimuli and procedures to check the reliability of the finding that EMG activity over selected muscles of expression varied as a function of the valence and intensity of affective stimuli. EMG activity was recorded from the brow, cheek, eye, forehead, lip, and forearm muscle regions while subjects viewed mildly to moderately affectively evocative slides. Subjects' faces were also unobtrusively videotaped during stimulus presentations.

Method

Subjects and Design

Twenty-eight healthy women between 18 and 24 years of age served as subjects in a 2 (replication) \times 2 (affective valence: positive or negative) \times 2 (affective intensity: mild or moderate) \times 8 (trials) mixed-model factorial, with the first factor varied between subjects.³ The experimental stimuli were ordered randomly across trials, and a separate random order was used for each of the two replications. Although the first and second within-subjects factors could be ordered in terms of their pleasantness and treated as a single factor with four levels (moderately unpleasant, mildly unpleasant, mildly pleasant, moderately pleasant), we partitioned these conditions into a 2 \times 2 design to examine the separate effects attributable to affective valence and affective intensity. If a measure varies simply as a function of the pleasantness of a stimulus, however, a main effect for valence and a Valence \times Intensity interaction result.

² Although not directly pertinent to the present discussion, it should be noted that for any given subject a pair of neutral polygons was associated with the onset of pleasant stimuli and the offset of unpleasant stimuli, and a second pair of neutral polygons was associated with the onset of unpleasant stimuli and the offset of pleasant stimuli (cf. Zanna, Kiesler, & Pilkonis, 1970). A funnel interview at the conclusion of the study indicated that subjects knew nothing about the unique relationship between particular polygons and affective stimuli. Analyses revealed that neither the measures of EMG activity obtained during the presentation of the polygons nor the measures of subjects' attitudes obtained at the end of the study provided any evidence of attitude conditioning. The absence of attitude conditioning might be due to the mild nature of the affectively evocative stimuli with which the polygons were paired.

³ Women alone served as subjects to minimize the error variance attributable to sex differences (e.g., regarding what visual stimuli are slightly pleasant versus slightly unpleasant) and to maintain same-sex conditions between subjects and experimenters.

Table 1
Mean Verbal Descriptions and Electromyographic Responses as a Function of Affective Valence and Intensity

Measure	Negative		Positive	
	Moderately	Mildly	Mildly	Moderately
Verbal descriptions				
Liking	2.09 _a	5.23 _b	5.78 _c	8.42 _d
Arousal	6.64 _a	5.27 _b	4.94 _b	5.08 _b
Familiarity	3.16 _a	4.82 _b	5.50 _c	5.74 _c
Electromyographic responses^a				
Corrugator supercilia	47.37 _a	46.21 _b	45.27 _b	42.22 _c
Zygomatic major	23.12 _a	23.50 _{ab}	24.04 _b	24.16 _b
Orbicularis oculi	28.39 _a	28.56 _a	28.83 _a	30.32 _b
Orbicularis oris	33.02 _a	33.73 _a	32.82 _a	33.58 _a
Medial frontalis	29.07 _{ab}	29.35 _b	28.65 _a	28.82 _{ab}
Superficial forearm flexor	23.50 _a	23.56 _a	23.25 _a	23.57 _a

Note. Means in a row with a similar subscript do not differ significantly by the Duncan multiple-range test ($p < .05$).
^a Entries represent the mean amplitude of transformed scores for EMG activity.

Results

Self-Report Measures

Discriminable episodes of mildly and moderately positive and negative affect were identified in the present study. The large F ratio for affective valence, $F(1, 25) = 199.58, p < .01$, indicated, as suggested earlier, that subjects in this study responded to the pleasant and unpleasant stimuli in the same manner as did subjects in the pilot testing. The Valence \times Intensity interaction was of course also significant, because the intensity factor was operationalized using subjects' responses on this scale, $F(1, 25) = 344.82, p < .01$. Cell means and pairwise comparisons are summarized in Table 1.

Analysis of the extent to which the scenes were reported to be arousing revealed main effects for affective valence, $F(1, 25) = 24.02, p < .01$, and affective intensity, $F(1, 25) = 27.21, p < .01$, and a Valence \times Intensity interaction, $F(1, 25) = 9.39, p < .01$. Inspection of Table 1 reveals that unlike the preceding pattern of data, photographs of moderately negative scenes were rated as being more arousing than were the remaining photographs. The analysis of the familiarity ratings also revealed main effects for affective valence, $F(1, 25) = 54.37, p < .01$, and affective intensity, $F(1, 25) = 13.83, p < .01$, and a Valence \times Intensity interaction, $F(1, 25) = 28.71, p < .01$. Briefly, the positive scenes were rated as being equally and relatively familiar, whereas the moderately unpleasant scenes were rated as being relatively novel (see Table 1).

Electromyographic Measures

A multivariate analysis of variance in which the mean amplitude of EMG activity over each of the six muscle regions served as a dependent measure revealed that the affectively evocative scenes had significant effects on EMG activity. The multivariate main effect for affective valence was significant, Wilk's criterion $F(6, 20) = 6.08, p < .01$, and as expected it was qualified by a significant multivariate Valence \times Intensity interaction, Wilk's criterion $F(6, 20) = 7.80, p < .01$.

Follow-up univariate analyses of variance revealed significant main effects for affective valence on the measures of EMG activity over the region of the corrugator supercilia, $F(1, 25) = 22.54, p <$

.01, zygomatic major, $F(1, 25) = 9.19, p < .01$, and orbicularis oculi, $F(1, 25) = 4.95, p < .05$. As summarized in Table 1, EMG activity over the corrugator supercilia muscle region was greater when unpleasant than when pleasant scenes were presented, whereas EMG activity over the zygomatic major and orbicularis oculi regions was greater when pleasant than when unpleasant scenes were presented.

Analyses also revealed Affective Valence \times Affective Intensity interactions for EMG activity over the facial regions of the corrugator supercilia, $F(1, 25) = 21.43, p < .01$, and the orbicularis oculi, $F(1, 25) = 5.57, p < .05$. As can be seen in Table 1, these significant interactions were attributable to the fact that EMG activity over the muscle region responsible for lowering and drawing the eyebrows together (corrugator supercilia) tended to be higher for moderately than for mildly intense unpleasant affective reactions, whereas it was lower for moderately than for mildly intense pleasant reactions. EMG activity over the muscle region controlling the actions of squinting (orbicularis oculi) showed the opposite pattern. No other tests were significant.⁷

Discussion

The present results challenge the conventional wisdom in social psychology that physiological measures are sensitive only to

⁷ We initially considered and rejected the notion of performing linear trend analyses on these means because (a) there is a long history of attempts to detect distinct physiological reactions that mark both the valence and the intensity of momentarily reportable affective states (e.g., see Cook & Sellitz, 1964) and (b) trend analyses are inappropriate because the valence and intensity conditions represent qualitative rather than quantitative categories (cf. Winer, 1971, pp. 388-390). A reviewer requested that we nevertheless calculate linear contrasts to test more directly our hypothesis that facial EMG activity over localized areas varies as a function of the pleasantness/unpleasantness of the affective reaction. We did so and, as expected, the results revealed significant linear trends for mean amplitude over the corrugator supercilia, $F(1, 25) = 65.05, p < .01$, orbicularis oculi, $F(1, 25) = 14.82, p < .01$, and zygomatic major, $F(1, 25) = 8.48, p < .01$, muscle regions.

Finally, Spearman correlation coefficients were calculated to examine the relation between the mean level of EMG activity recorded over each site and the reported familiarity and arousing effects of the stimuli. None of these correlations approached significance ($-.10 < r_s < .10$).

the former individual was repulsed by the other. To summarize thus far, then, measures of facial EMG and of observable facial actions each have unique advantages and disadvantages, with neither necessarily being "better" or capable of capturing completely the information provided by the other.

Because the present research indicates that facial EMG activity varies as a function of the direction and the intensity of affective reactions, and because the absence of a physiological measure that varied as a function of the direction and intensity of affective reactions has long been held to be a major obstacle in the development of a physiological measure of attitudes (cf. McGuire, 1985), the utility of facial EMG as a physiological measure of attitudes warrants comment. Electrodermal activity (e.g., Rankin & Campbell, 1955), pupil size (e.g., Hess, 1965), and heart rate (e.g., Katz, Cadoret, Hughes, & Abbey, 1965) have all been used to study attitudes, but these physiological measures have at best proven sensitive to variations in the extent of strong emotion underlying an attitude (cf. Cacioppo & Sandman, 1981; Petty & Cacioppo, 1983; Zanna, Detweiler, & Olson, 1984). Although measures of facial efferece may overcome this particular problem, we do not envision facial EMG as an effective physiological measure of attitudes in many contexts. At the simplest level, people are capable of suppressing, falsifying, and distorting their facial expressions, which makes it difficult to determine their true feelings toward a stimulus using measures of facial actions, at least in some settings (Zuckerman, Larrance, Spiegel, & Klorman, 1981; cf. Cacioppo & Petty, in press-a).

Second, attitudes are generally conceived of as global and enduring evaluations of a stimulus (e.g., Petty & Cacioppo, 1981; Zanna & Rempel, 1984). People's positive attitudes toward their children endure despite moments of displeasure and occasional thoughts of abandonment. Facial efferece, on the other hand, can be extremely transient and specific, marking perhaps a positive thought and feeling one moment and the realization of an undesirable consequence the next. This is not to say that attitudes and facial EMG will never covary; when people are left to simply think about an unequivocally counterattitudinal versus proattitudinal topic, for instance, the predominant thought and feeling can be expected to vary so dramatically and consistently that facial EMG should differentiate the individuals in these conditions (Cacioppo & Petty, 1979). But the same general factors mitigating attitude-behavior correspondence when comparing a general measure of attitude with a specific measure of behavior can also be expected to vitiate the correspondence between a person's general and enduring attitude toward a stimulus and the facial efferece associated with transient, specific, and possibly issue-irrelevant (e.g., a speaker's facial expression; cf. McHugo, Lanzetta, Sullivan, Masters, & Englis, 1985) affective reactions.

Third, conditions can be anticipated in which even *general* expressions of attitudes and of affect diverge. Avid smokers, for instance, may generally hold that the consumption of cigarettes is foolish, harmful, and negative but nevertheless have consistent and general positive affective reactions to the act of smoking cigarettes (Fishbein, 1980; see also Englis et al., 1982).

Finally, the accessing of one's attitude toward a stimulus can but need not be accompanied by an unequivocal affective reaction. For instance, mild affective reactions habituate with repeated presentations of a stimulus, yet people's evaluations of the stimulus need not become neutral (e.g., Hare, 1973). Similarly, individuals appear able to categorize a familiar stimulus

as being good or bad with minimal, if any, affective involvement (e.g., Cacioppo & Petty, 1980; Cacioppo, Petty, & Morris, 1985; Gordon & Holyoak, 1983). This is not to suggest that affect cannot precede inferences, but simply to suggest that individuals, like well-programmed computers, can access a previously formulated attitude and can perhaps even apply a set of criteria to categorize a stimulus as being "good" or "bad," "wise" or "foolish," or "harmful" or "beneficial" without invoking emotion. To the extent that this analysis is accurate, at least in relative if not in absolute terms, then interesting questions arise regarding the differences in the consequences of social judgments (e.g., attitudes, attributions, and inferences) grounded primarily in cognition and those based primarily in affect.

Although the present research was not designed to address questions about the role of facial efferece in affective experience, the observed correspondence between subtle patterns of facial efferece and subjects' transient and idiosyncratic affective reactions is certainly consistent with the view that facial efferece is a significant determinant of emotion. It is also consistent with the view emphasized earlier that facial efferece can serve as emotional readout. It is possible, for instance, that subjects in the present study rated their affective reactions as more intense *because* greater discriminably patterned feedback had been evoked. Research on the temporal specificity of striated muscular activity (e.g., Henneman, 1980; Willis & Grossman, 1977), facial actions (e.g., Ekman & Friesen, 1978), and facial EMG activity (e.g., Cacioppo et al., 1984) is clearly consistent with recent arguments that the temporal parameters of the efferece resulting from spontaneous versus deliberate facial actions are distinguishable, just as are the spatial parameters that differentiate the feedback resulting from expressions of, say, happiness and sadness (cf. Tomkins, 1981).

As is well known, evidence has also been reported questioning the contributions of facial efferece to affective experience (cf. Tourangeau & Ellsworth, 1979). However, several mechanisms of action linking spontaneous facial efferece to affective experience can be suggested that do not cast the relation between facial efferece and affective experience as an invariant. In addition to innate afferent mechanisms (e.g., Izard, 1977; Tomkins, 1962, 1963), one might point to the processes of classical conditioning (wherein facial feedback from spontaneous expressions of emotion has been paired so frequently with particular emotional experiences that this feedback has come to serve as a conditioned stimulus), self-perception (e.g., why would one smile spontaneously at another unless liking was involved), and behavioral confirmation (e.g., facial expressions, like overt actions toward another, should influence the social feedback individuals receive). Although deliberate facial expressions of emotion may invoke some of these mechanisms in a weakened form (e.g., even the effects attributable to social feedback should be weakened by leakage from other channels—cf. Zuckerman, Larrance, et al., 1981), the construction and maintenance of a deliberate expression of emotion and the monitoring of the communicative effectiveness of the expression can also subsume processing capacity. When an individual's processing resources are sufficiently limited in an emotionally evocative context that the capacity allocated to the construction, maintenance, and monitoring of an expressive display diminishes what can be allocated to the evocative stimulus, then one might expect deliberate expressions of emotion to actually attenuate the affective experience or to

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