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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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capable of more complex and variable actions than are captured by the notion of general arousal.[1] Why this might be so is apparent when the purpose of efference is considered. The somatic nervous system is the final pathway through which people interact with and modify their physical and social environments. That the pattern of efference is not always as intended (e.g., as when one performs clumsily), not always a veridical reflection of goals (e.g., as when one deceives), and not always obvious (e.g., as when one hides feelings) is important to recognize (e.g., see Ekman & Friesen, 1975). But without efference, individuals do not communicate, do not affiliate, do not proliferate, do not interact—in short, are not social. It is conceivable, therefore, that analyses of the patterns of efference may be of interest to social psychologists. Even efferent discharges that are too subtle or fleeting to be observable under normal conditions of social interaction may be of interest because these are less likely to undergo the same distortions as overt actions and expressions.

Moreover, the muscles of facial expression may be especially noteworthy to social psychologists in that these somatic effectors are linked to connective tissue and fasciae rather than to skeletal structures; their influence on the social environment, therefore, is often mediated by the construction of facial configurations rather than by direct action through the movement of the skeletal structure (Ekman & Friesen, 1975; Izard, 1971; Rinn, 1984). There is now a growing literature on these facial configurations (a) supporting Darwin's (1872/1965) notions regarding their evolutionary history and adaptive utility (e.g., Ekman, 1972, 1982a; Ekman, Friesen, & Ellsworth, 1982), (b) highlighting their capacity as social stimuli (e.g., Englis, Vaughan, & Lanzetta, 1982; Lanzetta & Orr, 1980, 1981; Sorce, Emde, Campos, & Klinnert, 1981), and (c) documenting the associated movements accompanying intrapersonal processes such as silent language processing and emotion (see recent reviews by Ekman & Oster, 1979; Fridlund, Ekman, & Oster, in press; McGuigan, 1978; Zuckerman, DePaulo, & Rosenthal, 1981). We are concerned in the present article with the latter focus.

Not all intrapersonal processes are accompanied by visually or socially perceptible expressive facial actions and, although there are several notable exceptions (cf. Ekman, 1972; Ekman, Friesen, & Ancoli, 1980; Haggard & Isaacs, 1966), this fact has limited the utility of research linking facial actions to psychological processes of interest in social psychology. Rajecki (1983, pp. 204–207), for instance, compared subjects' aggressive behavior using a standard social psychological measure—the Buss (1961) aggression machine test—with their simultaneous facial expressions. Rajecki reported that although "angry" subjects delivered significantly greater electric shock to their partner than did "not angry" subjects, there was no consistent relationship between aggression measured in the standard fashion and motivation or emotion as revealed in subjects' visually observable facial expressions. Similarly, Graham (1980) attempted to assess viewers' emotional responses to television advertisements using Ekman and Friesen's (1978) exhaustive Facial Action Coding System (FACS). Although Graham noted that his results are still preliminary, analyses of the data from 20 subjects indicated "too few content-related facial expressions were displayed to make FACS scoring worthwhile" (p. 342). However, the neural activation of the striated muscles results in muscle action potentials (MAPs) that can be detected using electromyography (EMG) even when there are no perceptible muscle contractions. This raises the interesting possibility that social processes too fleeting or subtle to evoke an overt expression can nevertheless be tracked.

Existing data provide support for this idea. For instance, Love (1972) videotaped people's facial expressions while they were exposed to a proattitudinal or counterattitudinal appeal and reported detecting no differences in overt expression. Cacioppo and Petty (1979) subsequently replicated this (null) finding while also demonstrating that the mean amplitude of EMG activity recorded over selected muscle regions of facial expression (e.g., corrugator supercilia, zygomatic major, depressor anguli oris) differentiated subjects exposed to a proattitudinal appeal from those exposed to a counterattitudinal appeal. Expanding on the research by Ekman et al. (1980), McHugo (1983) examined the facial EMG responses of individuals as they viewed excerpts of videotapes. McHugo found that the EMG activity over the zygomatic major (cheek) and corrugator supercilium (brow) muscle regions varied as a function of subjects' emotional reactions to the excerpts. The procedures employed in this research make it unlikely that socially observable expressions of emotion were evinced by subjects, although assessments regarding the overt nature of the facial actions observed using EMG were not reported.

Studies of emotional and attitudinal imagery have provided further evidence that, even in the absence of overt facial movements, positive and negative affective states can lead to localized changes in facial EMG activity. Fridlund, Schwartz, and Fowler (1984), for instance, demonstrated the utility of facial EMG activity in discriminating among subtle facial expressions observed during distinctive emotional imagery states, and Cacioppo, Petty, and Marshall-Goodell (1984) found that localized changes in EMG activity differentiated trials on which subjects imagined reading agreeable and disagreeable editorials. The most consistent finding in this area of research is that EMG activity over the corrugator supercilium muscle (whose action draws the brows together) region is higher and that EMG activity over the zygomatic major muscle (whose action draws the end of the mouth up and back) region is lower during negative than positive emotional episodes (cf. Cacioppo & Petty, 1981; Fridlund & Izard, 1983; Schwartz, 1975). It should be noted, however, that whether or not these facial EMG responses mark the intensity as well as the valence of positive and negative affective reactions has yet to be determined.

Pilot Study

To provide preliminary data regarding the idea that EMG activity over the muscles of facial expression generally, and over the brow and cheek regions in particular, varies as a function of the valence and intensity of people's affective reactions to mildly evocative stimuli, 16 undergraduates were exposed to mildly and moderately positive and negative visual and auditory stimuli. A paradigm similar to that used by Zanna, Kiesler, and Pilkonis (1970) was employed in this study. Positive scenes were accompanied by a mildly pleasant tone, and negative scenes were accompanied by a mildly unpleasant tone. The scenes and tones were presented simultaneously for 4.5 s, and each compound

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[1] We use the term *efference* rather than *response,* following Zajonc's (1985) argument that the former has fewer a priori implications regarding the role of efference in the production of affect.

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) × 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 × Intensity interaction on the measure of EMG activity over the corrugator supercilia region, $F(1, 14) = 9.03$, $p < .01$. Briefly, the facial efference to the brow region decreased as the subjects' affective reaction to the compound stimulus became more positive, whereas the efference 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 × 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 × 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) × 2 (affective valence: positive or negative) × 2 (affective intensity: mild or moderate) × 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 × 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 × Intensity interaction result.

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[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.

Stimulus Materials

The affectively evocative slides to which subjects were exposed were selected in preliminary research using volunteers from the same subject population. Twenty-four photographs were selected because they were judged consistently to be mildly to moderately pleasant, and 24 were chosen because they were consistently judged to be mildly to moderately unpleasant. An attempt was made to select a wide variety of scenes, some of which were mildly exciting or upsetting to view (e.g., a mountain cliff or a bruised torso) and others of which were mildly relaxing or boring to view (e.g., an ocean beach or a polluted roadway). Pilot testing also revealed that although there was consistency across individuals in their ratings of the affective valence of a given photograph, there was little consistency across individuals in terms of the rated intensity of the affect evoked by a given photograph. Hence, we decided following pilot testing (a) to use the a priori classifications for the affective valence factor but (b) to perform a median split of the liking ratings provided by each subject to determine which positive stimuli were liked mildly versus moderately and (c) to perform a second median split to determine which negative stimuli were disliked mildly versus moderately. Thus, each subject's median likeability rating within each affective valence condition was used to define affective intensity.[4] Although using each subject's own rating of emotional arousal after each 5-s trial to define the intensity factor means that one cannot determine whether the affective experience resulted in efferent discharges or the facial efference influenced the affective experience, or both, the present investigation is not compromised because the issue is whether an association exists between facial efference and people's transient and idiosyncratic affective reactions.

Procedure

To reduce apprehension about participating in the study, subjects attended an introductory lecture on psychophysiological recording, were led to believe that the study concerned the effects of affective stimuli on involuntary neural processes, completed several questionnaires (e.g., a health status questionnaire), and toured the laboratory several weeks prior to their participation. Subjects were unaware that physiological responses over which they had control were being monitored (cf. Cacioppo, Petty, & Marshall-Goodell, 1985).

Surface EMG activity was recorded using miniature Ag/AgCl electrodes placed in pairs over the corrugator supercilia, zygomatic major, orbicular oris, orbicularis oculi, and medial frontalis regions on the left side of the face to gauge the MAPs from the regions of the muscles of facial expression, and over the nonpreferred superficial forearm flexors to assess somatic activity in a peripheral region. To reduce subject awareness of the experimental hypotheses, subjects were told that the study concerned the natural, involuntary physiological reactions evoked by complex visual stimuli such as photographs, and additional dummy electrodes were placed on the head and torso to divert attention from the face as the particular site of interest. EMG signals obtained from surface, in contrast to needle, electrodes are less precise in isolating the specific source of MAPs because they generally reflect the MAPs from a cluster of heterogeneous motor units rather than from a single unit. However, although the details of individual MAPs are lost in surface EMG recordings, the discrete microvolt discharges from individual MAPs summate spatially and temporally during motor-unit recruitment to yield an aggregate indicating the action (or inaction) of motoneuron pools. Moreover, this aggregate response develops in an orderly manner from the individual MAPs such that progressively larger motoneurons are added to, or progressively smaller units are subtracted from, the total input from a motoneuron pool. Thus, changes in the amplitude of the integrated EMG provide a reliable and valid index of changes in MAP activity (e.g., Henneman, 1980; Lippold, 1967; cf. Cacioppo, Marshall-Goodell, & Dorfman, 1983; Fridlund & Izard, 1983).

Prior to the onset of the experimental trials, subjects underwent a 10-min period of progressive relaxation to minimize general somatic activity. Subjects were then instructed to examine each slide projected onto a screen, which was situated 1.5 m in front of them, and to answer the questions posed after the presentation of each scene. Questions were posed on a 22.86-cm (9-in.) videoscreen suspended in front of the subject, and responses were made using a numeric keypad.

Subjects were exposed to an initial 16 buffer slides to ensure habituation to the procedure and to another 32 slides during which data were collected. Subjects were unaware of the total number of trials or of the transition between the buffer and experimental trials. Each slide was presented for 5 s. After each presentation, subjects used 9-point scales to rate how much they liked the depicted scene (1 = *disliked*, 9 = *liked*), how aroused it made them feel (1 = *relaxed*, 9 = *aroused*), and how familiar the scene appeared (1 = *novel*, 9 = *familiar*). A closed-loop baseline was employed such that the next slide was presented only after subjects had returned to and maintained basal levels of somatic activity for 5 s (cf. McHugo & Lanzetta, 1983).[5]

Data Reduction

The EMG signals were relayed through shielded cable to Grass wide-band ac-preamplifiers, where they were rectified and smoothed using contour-following integrators with time constants of 0.02 s. The preamplifiers were calibrated to yield a full-scale deflection of an 80-μV signal, and the integrator thresholds were adjusted to place the zero signal at 2% of full-scale deflection. Each channel of EMG was transmitted on-line to a laboratory computer, digitized at a rate of 100 samples per second, and stored on a hard disk. In addition, during the study the rectified and smoothed EMG recordings were displayed on a polygraph, raw EMG recordings were intermittently checked using an oscilloscope, and subjects were monitored and videotaped using a videocamera housed unobtrusively in a speaker. Subsequently, data were deleted for trials on which artifacts were detected or for which the response exceeded full-scale deflection (i.e., 80 μV). Finally, EMG activity recorded over each region was denoised in quadrature, mean amplitude of EMG activity over each region was determined, and the mean amplitudes were averaged across trials but within subjects to obtain more reliable and normally distributed estimates of treatment effects.[6]

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[4] Larry Gant and Kathy Morris were very helpful in the selection and pilot testing of these stimuli. Their assistance is gratefully acknowledged.

[5] There was no difference across conditions in the time required by subjects to reach the criterion before proceeding to the next experimental trial. For an excellent discussion of the closed-loop baseline, see McHugo and Lanzetta (1983).

[6] The videotapes of subjects were visually inspected to determine whether noticeable facial expressions were exhibited during the 5-s stimulus period. The data obtained during trials in which a change in facial expression could be detected were deleted prior to analyses, and in all but one case such instances were rare (i.e., < 3%) and equally distributed across conditions. One subject, however, consistently displayed detectable facial actions during this period. Because data from most of the trials for this individual exceeded 80 μV, her data were deleted prior to analyses.

We also wish to thank A. J. Fridlund for his advice concerning denoising in quadrature, which is a procedure designed to maximize the signal-to-noise ratio in complex waveforms such as the EMG. The transformation used is

$$[Y_i^2 - Y_{(\min)}^2]^{1/2},$$

where $Y_{(\min)}$ represents the minimum signal observed in a given channel during a given session (expressed in microvolts) and Y_i represents the *i*th element in the digital array corresponding to the EMG activity during a given trial.

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

	Negative		Positive	
Measure	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 × 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 × 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 × 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 × 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 × 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

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[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 & Selltiz, 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 ($-.10 < rs < .10$).

changes in general arousal and therefore cannot be used to distinguish between positive and negative affect. The obtained pattern of EMG data indicates a selective activation and inhibition of MAP activity across specific facial muscle regions. This result, together with the electrodermal data from the pilot study and verbal reports regarding felt arousal from the main study, makes it unlikely that the detected EMG responses are due simply to a general increase in arousal or to an increased tensing of the muscles during the presentation of a positive or negative stimulus. Recall, too, that a given positive or negative scene served as a mild affective stimulus for some subjects whereas it served as a moderate affective stimulus for others. Hence the gradations of facial EMG activity found in the present study are more likely to be attributable to the subjects' psychological reaction to the stimuli than to some irrelevant physical feature (e.g., luminosity). Moreover, the pleasantness of emotional reactions has been shown previously to influence the facial actions over the brow (corrugator supercilia) and/or cheek (zygomatic major) regions (e.g., Ekman et al., 1980; Ekman & Friesen, 1978; McHugo, 1983; Schwartz, 1975). The EMG responses obtained in the present study fit well with this previous research and suggest that facial expressions of emotion—like perioral activity during silent language processing and bodily activity during imagery—can occur so subtly as to go unnoticed in normal social settings (cf. Cacioppo & Petty, 1981).

The one unexpected outcome in the present study concerned the EMG activity obtained over the orbicularis oculi (periocular) muscle region. EMG recordings from this region have been shown to be heightened by expressions of pain, squinting, and so forth (e.g., Englis et al., 1982). Activity over this region in the present study, therefore, may simply reflect eye movements and fixations rather than incipient facial actions associated with affect. On the other hand, EMG activity over this muscle region was greater when positive than when negative stimuli were presented even when a focal point was used (see Pilot Study).

Yet another interesting account for these data is based on Ekman and Friesen's (1982) important work on "felt" smiles. Ekman and Friesen (1982) suggest that people display a smile—whether happy or not—when they wish to present a happy image but that people display both a smile and crow's feet at the outer edges of their eyes when they *feel* happy. Ekman and Friesen (1982) hypothesize that the common elements in the facial expression of the person who actually experiences a positive emotion are the action of two muscles: "the zygomatic major pulling the lip corners upwards towards the cheekbone; and the orbicularis oculi which raises the cheek and gathers skin inwards from around the eye socket" (p. 242). Because there was no reason in the present setting for subjects to feign positive affective reactions to the experimental stimuli, it is possible that the heightened EMG activity over the orbicularis oculi region, which we found to differentiate the affective nature of the experimental stimuli, may have been related to the variations in the subjects' *feelings* of positive regard for the depicted scenes.

Indeed, a general congruence between results based on facial EMG recordings and those obtained through fine-grain analyses of overt expressions is to be expected because

> facial expressions are principally the result of stereotyped movements of facial skin and fascia (connective tissue) due to contraction of the facial muscles in certain combinations. Such contractions create folds, lines, and wrinkles in the skin and cause movements of facial landmarks such as mouth corners and eyebrows. (Rinn, 1984, p. 52)

Yet the redundancy between these procedures is only partial. For instance, EMG recordings can reveal MAP activity too small to evoke detectable movements and/or whose corresponding muscle contraction is counteracted by contraction of an antagonist.[8] In an interesting illustration of this principle, Ekman, Schwartz, and Friesen (reported in Ekman, 1982b) simultaneously secured videorecordings and surface EMG recordings of individuals as they deliberately intensified the contraction of specific facial muscles (corrugator supercilia and medial frontalis). Results revealed that measurements from FACS and from surface EMG over these muscle regions were highly correlated ($r = .85$). Nevertheless, reliable EMG signals emerged at levels of MAP activity that were lower than could reliably be detected visually. An implication of the former result is that the wealth of information that exists regarding overt facial displays during communication, deception, and emotion should provide a rich theoretical resource for research on subtler, more fleeting discharges of facial efference. An implication of Ekman, Friesen, and Schwartz's latter finding is that the absence of visually detectable facial actions does not rule out the possibility of tracking at least limited features of moment-by-moment affective processes.

The social context in which facial efference is measured is also important (cf. Ekman & Friesen, 1975). Facial actions can serve communicative and emotionally expressive functions, but they can also serve to deceive; they are controllable, yet they are not always controlled:

> Whereas sounds and the body movements that illustrate speech are intermittent, the face even in repose may provide information about some emotion or mood state. Many nonverbal behaviors simply do not occur when a person is alone, or at least do so very rarely. For example, it would be unusual for someone to shrug or gesture hello when totally alone. Yet facial expressions of emotion may be quite intense even when a person is alone. They are not occasioned only by the presence of others. In fact, social situations can dampen facial expression of emotion. (Ekman, 1982b, p. 45)

The display rules and contingencies that govern overt facial expressions in social contexts may well be less powerful and less likely to influence patterns of facial efference when the efference is so subtle or fleeting as to be undetectable by observers. If this is in fact the case, then discrepancies between the MAP activity underlying covert versus overt facial expressions may be of interest in much the same manner as are discrepancies between private and public actions. For instance, consider an individual who, upon seeing a familiar person approaching at a distance, shows an elevation in EMG activity over the corrugator supercilia muscle region, a diminution in EMG activity over the zygomatic major and orbicularis oculi regions, and yet maintains what appears to be an expressionless face. As the two approach more closely, the pattern of efference changes dramatically as the individual smiles broadly. The striking discrepancy between the facial efference associated with incipient versus public facial displays would at least raise the otherwise unnoticed possibility that

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[8] FACS, on the other hand, remains the only available comprehensive coding system for quantifying observable facial actions. For further discussion of the unique advantages of visual scoring procedures, see Ekman (1982b).

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 efference 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 efference, 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 efference 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 efference in affective experience, the observed correspondence between subtle patterns of facial efference and subjects' transient and idiosyncratic affective reactions is certainly consistent with the view that facial efference is a significant determinant of emotion. It is also consistent with the view emphasized earlier that facial efference 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 efference 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 efference to affective experience (cf. Tourangeau & Ellsworth, 1979). However, several mechanisms of action linking spontaneous facial efference to affective experience can be suggested that do not cast the relation between facial efference 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 experience or to introduce feelings of negative affect such as anxiety or distress. For instance, expressing and maintaining an unfelt smile in the face of danger may prove to be an effective means of attenuating fear because of the disruption of the normal (i.e., spontaneous) pattern of efference and feedback found in this situation *and* because of the reduction in the processing capacity that can be allocated to the fear-evoking situation.[9]

In sum, previous research has demonstrated that overt facial expressions vary as a function of people's emotional reactions and that the electromyogram is an effective technology for examining neuromuscular actions in the absence of overt muscle contractions. The results of the present research point to a procedure for tracking affective processes. Specifically, results indicated that facial EMG can mark the valence and intensity of transient and specific affective reactions even in the absence of emotional expressions that are noticeable, at least under normal viewing conditions. Although the pattern of facial efference is unlikely to yield a satisfactory physiological marker of attitudes per se, the present results do suggest that facial EMG may provide a useful technology for tracking the rudimentary positive or negative feelings a person has toward a stimulus and the more elementary processes underlying a variety of social judgments and behaviors such as attitude development and change. For instance, whether episodes of "instrumental" and "hostile" aggression studied in social psychological laboratories differ in terms of their emotional underpinnings (cf. Rajecki, 1983) and whether cognitive dissonance is characterized phenomenologically by the perception of arousal or by an unpleasant affective reaction (see recent reviews by Fazio & Cooper, 1983; Cacioppo & Petty, in press-b) are questions that should be amenable to psychophysiological probes.

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[9] Of course, deliberately constructed facial expressions should not have this effect on affective experience when the expression is automatic, the emotionally evocative stimulus requires little processing capacity, or the emotionally evocative stimulus persists sufficiently long that any diminution of processing resources that can be allocated to the stimulus becomes trivial.

References

Breckler, S. J. (1984). Empirical validation of affect, behavior, and cognition as distinct components of attitude. *Journal of Personality and Social Psychology, 47,* 1191–1205.

Buss, A. H. (1961). *The psychology of aggression.* New York: Wiley.

Cacioppo, J. T., Marshall-Goodell, B., & Dorfman, D. D. (1983). Skeletomuscular patterning: Topographical analysis of the integrated electromyogram. *Psychophysiology, 20,* 269–283.

Cacioppo, J. T., & Petty, R. E. (1979). Attitudes and cognitive response: An electrophysiological approach. *Journal of Personality and Social Psychology, 37,* 2181–2199.

Cacioppo, J. T., & Petty, R. E. (1980). The effects of orienting task on differential hemispheric EEG activation. *Neuropsychologia, 18,* 675–683.

Cacioppo, J. T., & Petty, R. E. (1981). Electromyograms as measures of extent and affectivity of information processing. *American Psychologist, 36,* 441–456.

Cacioppo, J. T., & Petty, R. E. (in press-a). Physiological responses and advertising effects: Is the cup half full or half empty? *Psychology and Marketing.*

Cacioppo, J. T., & Petty, R. E. (in press-b). Social processes. In M. G. H. Coles, E. Donchin, & S. Porges (Eds.), *Psychophysiology: Systems, processes, and applications.* New York: Guilford Press.

Cacioppo, J. T., Petty, R. E., & Marshall-Goodell, E. (1984). Electromyographic specificity during simple physical and attitudinal tasks: Location and topographical features of integrated EMG responses. *Biological Psychology, 18,* 85–121.

Cacioppo, J. T., Petty, R. E., & Marshall-Goodell, E. (1985). Physical, social, and inferential elements of psychophysiological measurement. In P. Karoly (Ed.), *Measurement strategies in health psychology* (Vol. 1, pp. 263–300). New York: Wiley.

Cacioppo, J. T., Petty, R. E., & Morris, K. J. (1985). Semantic, evaluative, and self-referent processing: Memory, cognitive effort, and somatovisceral activity. *Psychophysiology, 22,* 371–384.

Cacioppo, J. T., & Sandman, C. A. (1981). Psychophysiological functioning, cognitive responding, and attitudes. In R. E. Petty, R. M. Ostrom, & T. C. Brock (Eds.), *Cognitive responses in persuasion.* Hillsdale, NJ: Erlbaum.

Cook, S. W., & Selltiz, C. (1964). A multiple-indicator approach to attitude measurement. *Psychological Bulletin, 62,* 36–55.

Darwin, C. (1965). *The expression of the emotions in man and animals.* Chicago: University of Chicago Press. (Originally published 1872).

Ekman, P. (1972). Universal and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska Symposium on Motivation* (Vol. 19). Lincoln: University of Nebraska Press.

Ekman, P. (1982a). *Emotion in the human face* (2nd ed.). Cambridge, England: Cambridge University Press.

Ekman, P. (1982b). Methods for measuring facial action. In K. R. Scherer & P. Ekman (Eds.), *Handbook of methods in nonverbal behavior research* (pp. 45–90). Cambridge, England: Cambridge University Press.

Ekman, P., & Friesen, W. V. (1975). *Unmasking the face.* Englewood Cliffs, NJ: Prentice-Hall.

Ekman, P., & Friesen, W. V. (1978). *Facial coding action system (FACS): A technique for the measurement of facial actions.* Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1982). Felt, false, and miserable smiles. *Journal of Personality and Social Psychology, 39,* 1125–2234.

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

Ekman, P., Friesen, W. V., & Ellsworth, P. (1982). Research foundations. In P. Ekman (Ed.), *Emotion in the human face* (2nd ed., pp. 1–143). New York: Cambridge University Press.

Ekman, P., & Oster, H. (1979). Facial expressions of emotion. *Annual Review of Psychology, 30,* 527–554.

Elkin, R. A., & Leippe, M. R. (1985). *Physiological arousal, dissonance, and attitude change: Evidence for a dissonance-arousal link and a "don't remind me" effect.* Manuscript submitted for publication.

Englis, B. G., Vaughn, K. B., & Lanzetta, J. T. (1982). Conditioning of counter-emphatic emotional responses. *Journal of Experimental Social Psychology, 18,* 375–391.

Fazio, R. H., & Cooper, J. (1983). Arousal in the dissonance process. In J. T. Cacioppo & R. E. Petty (Eds.), *Social psychophysiology: A sourcebook* (pp. 122–152). New York: Guilford Press.

Fishbein, M. (1980). A theory of reasoned action: Some applications and implications. In H. Howe & M. Page (Eds.), *Nebraska Symposium on Motivation* (Vol. 27). Lincoln: University of Nebraska Press.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research.* Reading, MA.: Addison-Wesley.

Fowles, D. C. (1980). The three arousal model: Implications of Gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathy. *Psychophysiology, 17,* 87–104.

Fridlund, A. J., Ekman, P., & Oster, H. (in press). Facial expressions of emotion: Review of literature, 1970–1983. In A. Siegman (Ed.), *Nonverbal communication.* Hillsdale, NJ: Erlbaum.

Fridlund, A. J., & Izard, C. E. (1983). Electromyographic studies of facial expressions of emotions and patterns of emotion. In J. T. Cacioppo & R. E. Petty (Eds.), *Social psychophysiology: A sourcebook* (pp. 243–286). New York: Guilford Press.

Fridlund, A. J., Schwartz, G. E., & Fowler, S. C. (1984). Pattern recognition of self-reported emotional state from multiple-site facial EMG activity during affective imagery. *Psychophysiology, 21,* 622–637.

Gordon, P. C., & Holyoak, K. J. (1983). Implicit learning and generalization of the "mere exposure" effect. *Journal of Personality and Social Psychology, 45,* 492–500.

Graham, J. L. (1980). A new system for measuring nonverbal responses to marketing appeals. *1980 AMA Educator's Conference Proceedings, 46,* 340–343.

Haggard, E. A., & Isaacs, F. S. (1966). Micromentary facial expressions as indicators of ego mechanisms in psychotherapy. In C. A. Gottschalk & A. Averback (Eds.), *Methods of research in psychotherapy.* New York: Appleton-Century-Crofts.

Hare, R. D. (1973). Orienting and defensive responses to visual stimuli. *Psychophysiology, 10,* 453–464.

Henneman, E. (1980). Organization of the motoneuron pool: The size principle. In V. E. Mountcastle (Ed.), *Medical physiology* (14th ed., Vol. 1). St. Louis, MO: Mosby.

Hess, E. H. (1965). Attitude and pupil size. *Scientific American, 212,* 46–54.

Higgins, E. T., Rhodewalt, F., & Zanna, M. P. (1979). Dissonance motivation: Its nature, persistence, and reinstatement. *Journal of Experimental Social Psychology, 15,* 16–34.

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

Izard, C. E. (1977). *Human emotions.* New York: Plenum Press.

Katz, H., Cadoret, R., Hughes, K., & Abbey, D. (1965). Physiological correlates of acceptable and unacceptable statements. *Psychological Reports, 17,* 78.

Kiesler, C. A., & Pallak, M. S. (1976). Arousal properties of dissonance manipulations. *Psychological Bulletin, 83,* 1014–1025.

Lanzetta, J. T., & Orr, S. P. (1980). Influence of facial expressions in the classical conditioning of fear. *Journal of Personality and Social Psychology, 39,* 1081–1087.

Lanzetta, J. T., & Orr, S. P. (1981). Stimulus properties of facial expressions and their influence on the classical conditioning of fear. *Motivation & Emotion, 5,* 225–234.

Lindzey, G., & Aronson, E. (1985). *Handbook of social psychology* (3rd ed.). New York: Random House.

Lippold, O. C. J. (1967). Electromyography. In P. H. Venables & I. Martin (Eds.), *Manual of psychophysiological methods* (pp. 245–298). New York: Wiley.

Love, R. E. (1972). *Unobtrusive measurement of cognitive reactions to persuasive communications.* Unpublished doctoral dissertation, Ohio State University.

McGuigan, F. J. (1978). *Cognitive psychophysiology: Principles of covert behavior.* Englewood Cliffs, NJ: Prentice-Hall.

McGuire, W. J. (1985). Attitudes and attitude change. In G. Lindzey & E. Aronson (Eds.), *Handbook of social psychology* (3rd ed., Vol. 2, pp. 233–346). New York: Random House.

McHugo, G. (1983, September). *Facial EMG and self-reported emotion.* Paper presented at the meeting of the Society for Psychophysiological Research, Asilomar, CA.

McHugo, G., & Lanzetta, J. T. (1983). Methodological decisions in social psychophysiology. In J. T. Cacioppo & R. E. Petty (Eds.), *Social psychophysiology: A sourcebook* (pp. 630–665). New York: Guilford Press.

McHugo, G., Lanzetta, J. T., Sullivan, D. G., Masters, R. D., & Englis, B. G. (1985). Emotional reactions to a political leader's expressive displays. *Journal of Personality and Social Psychology, 49,* 1513–1529.

Pallak, M. S., & Pittman, E. S. (1972). General motivation effects of dissonance arousal. *Journal of Personality and Social Psychology, 21,* 349–358.

Petty, R. E., & Cacioppo, J. T. (1981). *Attitudes and persuasion: Classic and contemporary approaches.* Dubuque, IA: William C. Brown.

Petty, R. E., & Cacioppo, J. T. (1983). The role of bodily responses in attitude measurement and change. In J. T. Cacioppo & R. E. Petty (Eds.), *Social psychophysiology: A sourcebook* (pp. 51–101). New York: Guilford Press.

Rajecki, D. W. (1983). Animal aggression: Implications for human aggression. In R. G. Geen & E. J. Donnerstein (Eds.), *Aggression: Theoretical and empirical reviews* (Vol. 1, pp. 189–211). New York: Academic Press.

Rankin, R. E., & Campbell, D. T. (1955). Galvanic skin response to Negro and white experimenters. *Journal of Abnormal and Social Psychology, 51,* 30–33.

Rinn, W. E. (1984). The neuropsychology of facial expression: A review of the neurological and psychological mechanisms for producing facial expression. *Psychological Bulletin, 95,* 52–77.

Schachter, S. (1964). The interaction of cognitive and physiological determinants of emotion. In P. H. Leiderman & D. Shapiro (Eds.), *Psychobiological approaches to social behavior.* Stanford, CA: Stanford University Press.

Schwartz, G. E. (1975). Biofeedback, self-regulation, and the patterning of physiological processes. *American Scientist, 63,* 314–324.

Sorce, J., Emde, R., Campos, J., & Klinnert, M. (1981, April). *Maternal emotional signaling; its effects on the visual cliff of one-year-olds.* Paper presented at the meeting of the Society for Research in Child Development, Boston.

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

Tomkins, S. S. (1963). *Affect, imagery, consciousness: The negative affects* (Vol. 2). New York: Springer.

Tomkins, S. S. (1981). The role of facial response in the experience of emotion: A reply to Tourangeau and Ellsworth. *Journal of Personality Social Psychology, 40,* 355–357.

Tourangeau, R., & Ellsworth, P. C. (1979). The role of facial response in the experience of emotion. *Journal of Personality and Social Psychology, 37,* 1519–1531.

Willis, W. D., & Grossman, R. G. (1977). *Medical neurobiology* (2nd ed.). St. Louis, MO: Mosby.

Wilson, E. O. (1975). *Sociobiology.* Cambridge, MA: Harvard University Press.

Winer, B. J. (1971). *Statistical principles in experimental design* (2nd ed.). New York: McGraw Hill.

Zajonc, R. B. (1985). Emotion and facial efference: A theory reclaimed. *Science, 228,* 15–21.

Zanna, M. P., Detweiler, R. A., & Olson, J. M. (1984). Physiological mediation of attitude maintenance, formation, and change. In W. Waid (Ed.), *Sociophysiology* (pp. 133–196). New York: Springer-Verlag.

Zanna, M. P., Kiesler, C. A., & Pilkonis, P. A. (1970). Positive and negative attitudinal affect established by classical conditioning. *Journal of Personality and Social Psychology, 14,* 321–328.

Zanna, M. P., & Rempel, J. R. (1984). *Attitudes: A new look at an old concept.* Paper presented at the Conference on Social Psychology of Knowledge, Tel Aviv, Israel.

Zuckerman, M., DePaulo, B. M., & Rosenthal, R. (1981). Verbal and nonverbal communication of deception. *Advances in Experimental Social Research, 14,* 1–59.

Zuckerman, M., Larrance, D. T., Spiegel, N. H., & Klorman, R. (1981). Controlling nonverbal displays: Facial expressions and tone of voice. *Journal of Experimental Social Psychology, 17,* 506–524.

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