Microexpressive Facial Actions as a Function of Affective Stimuli: Replication and Extension

John T. Cacioppo
Ohio State University
Lauren K. Bush
University of Washington
Louis G. Tassinary
Texas A & M University

The effects of communicative intent and stimulus affectivity on facial electromyographic (EMG) activity were investigated. Subjects viewed slides of pleasant, neutral, or unpleasant social or nature scenes under no instruction, inhibit-expression instructions, and amplify-expression instructions. Results revealed that facial EMG activity was highest in the amplify and lowest in the inhibit condition; EMG activity over the corrugator supercilii *region varied as a function of the affective valence of the stimuli regardless of instructional condition; and facial EMG activity did not differ when subjects were exposed to slides of nature versus social scenes that were matched for rated pleasantness. These results suggest that facial efference can be altered by both affective and communicative processes even when it is too subtle to produce a socially perceptible facial expression.*

The past two decades of research have led to a renaissance of detailed analyses of the actions of the striated muscles of the face during thought and emotion (e.g., Ekman, 1971, 1977; Izard, 1971, 1977). Research on incipient facial efference during emotional tasks using facial electromyography has also emerged during this period to complement fine-grained analyses of overt facial action (see Cacioppo, Tassinary, & Fridlund, 1990). Considerable evidence has now accumulated to suggest that distinctive configurations of facial actions are associated with at least a subset of emotional states (e.g., happiness, sadness, fear, anger, disgust). The psychological significance of these facial configurations continues to be debated, however. Jones, Collins, and Hong (1991, p. 45), for example, identified two major schools of thought on this issue: (a) Emotional experience automatically activates prewired patterns of expressive facial movements that go forward unless they are actively inhibited or modified by top-down processes, and (b) facial expressive movements are first and foremost evolved social displays that encode information about behavioral tendencies, not emotional states. Fridlund (1990), a vigorous proponent of the latter viewpoint, has argued that the facial configurations people identify with the emotions serve only a communicative function; that is, they do not vary as a function of emotional experience per se.

The evidence that facial expressions vary as a function of social motives is clear. Kraut and Johnston (1979), for instance, observed smiling in bowlers who scored a strike or spare. They reported that bowlers do not usually smile when the pins begin to fall; rather, they smile when they turn to face their companions. Fridlund (1991) suggested that facial displays also occur in *solitary* individuals when these individuals (a) treat themselves as social

---

Authors' Note: The data reported in this article are based on a master's thesis conducted by the second author under the supervision of the first. The authors would like to thank Craig Smith, Alan Fridlund, Stephen Crites, Mary Snydersmith, and Bert Uchino for comments on an earlier draft. Preparation of this article was supported by National Science Foundation Grant No. BNS-8818557/8940915 to the first author and a National Institute of Mental Health Postdoctoral Grant No. 5-T32-MH18931-02 to the second. Address correspondence concerning this article to John T. Cacioppo, Department of Psychology, Ohio State University, 1885 Neil Avenue, Columbus, OH 43210-1222; electronic mail: Cacioppo.1@osu.edu.

PSPB, Vol. 18 No. 5, October 1992 515-526

interactants, (b) act as though others were present when they are not, (c) imagine that others are present when they are not, (d) forecast interactions with others who are not immediately present, or (e) anthromorphize objects or nonhuman animals as interactants. Fridlund's analysis therefore suggests there is a high potential for implicit audiences in solitary individuals. Solitary individuals evidently are not always accompanied by an implicit audience, however. In Kraut and Johnston's (1979) study, for instance, solitary bowlers "rarely showed any facial displays or other gestures but instead maintained a generally neutral face" (p. 1546) even though they too scored strikes and spares and even though they were not alone in the bowling alley. Hence, questions remain about the conditions under which social motives are activated and influence facial displays.

There is also considerable evidence that facial actions reflect emotional experiences, although much of this evidence comes from the perception, rather than the production, of facial displays (see reviews by Ekman, 1989, 1992; Izard, 1990, 1992; Izard & Malatesta, 1987). Of particular interest here are studies of facial electromyographic (EMG) activity using weak affective stimuli, by which we mean stimuli that individuals judge to be mildly pleasant or mildly unpleasant. Facial efference can result in muscle action potentials that are too weak or brief to produce a visible facial action even though these muscular actions can be recorded continuously with facial electromyography. Evidence from several laboratories now indicate that (a) EMG activity over the brow (*corrugator supercilii*) muscle region is higher and EMG activity over the cheek (*zygomaticus major*) and periocular (*orbicularis oculi*) muscle regions is lower for unpleasant than pleasant stimuli, and (b) electromyography activity over the forehead (*medial frontalis*) and perioral (*orbicularis oris*) muscle regions does not consistently differentiate stimuli that are judged to be mildly pleasant versus mildly unpleasant (e.g., compare the results of Bush, Barr, McHugo, & Lanzetta, 1989; Cacioppo, Petty, Losch, & Kim, 1986; Cacioppo, Petty, & Marshall-Goodell, 1984; Dimberg, 1986, 1988; Englis, Vaughan, & Lanzetta, 1982; Greenwald, Cook, & Lang, 1989; McCanne & Anderson, 1987; McHugo, Lanzetta, & Bush, in press; McHugo, Lanzetta, Sullivan, Masters, & Englis, 1985; Schwartz, Fair, Salt, Mandel, & Klerman, 1976). Phasic facial EMG responses over the brow region have also been found to predict the momentary affective states of individuals who were being interviewed about themselves (Cacioppo, Martzke, Petty, & Tassinary, 1988; see also Teasdale & Rezin, 1978) and to vary systematically during sleep when aversive noise was presented (Sumitsuji, Nan'no, Kuwata, & Ohta, 1980). Because subjects were tested while alone (and in Sumitsuji et al., 1980, while asleep) and the EMG responses observed in several of these studies were unaccompanied by socially perceptible expressive facial movements, the EMG data from these studies have been interpreted as evidence that facial efference can also vary as a function of affective experience.

The notion that both social motives *and* affective experiences are related to facial expressions is not new. Darwin (1872/1873) suggested that the distinctive facial configurations associated with emotions were components of coherent neurophysiological systems that evolved because of their adaptive direct effects and/or social consequences. Expulsion of rancid material from the mouth in disgust is an example of a direct effect of "expressive" actions, whereas the decreased likelihood that conspecifics would eat rancid foodstuff having observed an association between the foodstuff and a disgust display is an example of a social consequence of facial displays. As this illustration suggests, configurations of facial actions may have evolved to serve multiple functions.

Research is needed, however, to determine whether and under what conditions social motives and affective experiences are related to distinctive muscular actions in the face. Consider, for instance, Dimberg's (1982) study of facial EMG activity while subjects viewed pictures of angry or happy faces. Dimberg found that EMG activity was higher over the brow muscle region and lower over the cheek muscle region when subjects viewed pictures of angry, in contrast to smiling, faces. In an attempt to clarify what these data meant, Dimberg (1986; Dimberg & Thell, 1988) conducted follow-up studies in which subjects were exposed to slides of fear-relevant stimuli (e.g., snakes) and fear-irrelevant stimuli (e.g., flowers). Results indicated that EMG activity was higher over the brow region and lower over the cheek region when subjects were exposed to the fear-relevant than the fear-irrelevant pictures. Dimberg interpreted this set of studies as indicating that "stimuli which are experienced as unpleasant and pleasant, elicit facial-EMG reactions that are interpretable as a negative and a positive emotional response, respectively" (Dimberg & Thell, 1988, p. 218). These data, however, may also reflect differences in the social motives that are usually evoked when confronting a smiling or scowling conspecific. Indeed, Fridlund (1990) has argued that expressive facial movements are exquisitely sensitive to minor variations in the evocative stimulus or social context and that these variations, through subtle effects on social motives, determine facial muscle contractions. Although contemporary theories do not tell us what these stimulus variations might be, one plausible candidate is the human face. If viewing facial displays of emotion, in contrast to viewing nature scenes, is particularly likely to activate social motives (or an implicit audience) in solitary subjects, then the incipient facial actions reported by Dimberg (1982) may be due to the activation of distinctive social motives rather than positive and negative affective reactions per se.[1]

To replicate and extend Dimberg's (1982) study, subjects in the present study viewed slides of social scenes (e.g., a person expressing emotions) and nature scenes (e.g., a mountain) that had been matched for rated pleasantness during pretesting. In addition, the pleasantness of the pictures shown to subjects was varied from mildly positive to mildly negative to replicate and extend our own research on facial EMG activity and affective experience (Cacioppo et al., 1986). We hypothesized that (a) because of the activation of distinct social motives, EMG activity over the cheek and periocular regions would be higher when subjects viewed smiling faces than when they viewed an equally pleasant nature scene, and EMG activity would be higher over the brow region when subjects viewed faces showing distress (e.g., anger, sadness) than when they viewed an equally unpleasant nature scene, and (b) because of the arousal of distinct feelings, EMG activity over the cheek and periocular regions would be higher, and EMG activity over the brow would be lower, when subjects viewed pleasant than unpleasant slides.

In the second portion of the study, we investigated the additional effects of specific social motives (*communicative intentions*) on facial EMG reactions to affective stimuli. We varied communicative intent by instructing subjects either to amplify or to inhibit the expression of their feelings about the image depicted in each slide to an implicit audience (i.e., an imaginary person sitting in front of them). Ekman (1979; Ekman & Friesen, 1982; Hager & Ekman, 1983) suggested that smiling can be a misleading marker of affect, and he suggested that detailed analyses of movements in the brow and periocular regions can disambiguate the nature of an individual's active reaction. The notion underlying Ekman's suggestion is that the actions of the muscles of the upper face are more likely to be a source of emotional leakage (and less likely to reflect communicative intentions) than the actions of the muscles of the lower face. Consistent with this reasoning, Ekman, Friesen, and O'Sullivan (1988) reported that crow's-feet at the outer edge of the eyes in combination with the smile differentiated individual's who were actually enjoying themselves from those feigning enjoyment. On the basis of Ekman and his colleagues' reasoning and research, we hypothesized that (a) EMG activity over the cheek muscle region would vary as a function of the valence of the stimulus when subjects were instructed to amplify, but not when they were instructed to inhibit, expressive movements of their face, whereas (b) EMG activity over the brow and periocular muscle regions would vary as a function of the valence of the stimulus even when subjects were instructed to inhibit expressive movements of the face.

METHOD

Subjects and Equipment

Twenty right-handed undergraduate women enrolled in an introductory psychology course served as subjects in a 2 (Stimulus Type: faces or scenes) × 3 (Affective Valence: positive, neutral, or negative) × 3 (Instructions: no instructions, amplify, inhibit) × 6 (Trials) within-subjects design.[2] To reduce apprehension and suspicion, subjects attended an introductory lecture on psychophysiological recording and were led to believe that the study concerned the effects of complex visual presentations on involuntary neural processes (Cacioppo et al., 1984). During the experimental session, subjects viewed slide presentations while surface EMG recordings over the brow (*corrugator supercilii*), periocular (*orbicularis oculi*), cheek (*zygomaticus major*), forehead (*medial frontalis*), lower mouth corner (*depressor anguli oris*), and perioral (*orbicularis oris*) muscle regions on the left side of the face were recorded following the guidelines outlined by Fridlund and Cacioppo (1986).[3] The preamplifiers and integrators were calibrated to yield a full-scale deflection to an 80-μV, 500-Hz square-wave signal, and the integrator thresholds were adjusted to place the zero signal at $\leq$ 1.6μVs. These recording procedures ensured that overt facial actions involving these muscles would exceed the measurement range, thereby facilitating identification and deletion of trials on which overt facial expressions were exhibited (Cacioppo et al., 1986).

Stimulus Materials

The slides of scenery pretested by Cacioppo et al. (1986) were supplemented with an equal number of slides showing facial expressions of emotion. Slides constituting these two sets (faces, scenes) were selected that were matched for their rated pleasantness as established in pilot testing. A total of 108 slides were shown, of which 36 had been judged consistently by pilot subjects to be mildly to moderately pleasant, 36 mildly to moderately unpleasant, and 36 neutral. An equal number of pleasant, neutral, and unpleasant slides, and an equal number of slides showing faces and scenes, were presented during each of the three instructional conditions in one of two random orders. Thus, subjects viewed the same number of slides in each condition, but no subject saw the same slide more than once during the experiment.

Procedure

When subjects arrived for participation in the study, miniature Ag/AgCl electrodes were placed in pairs over the *corrugator supercilii, orbicularis oculi, zygomaticus major, medial frontalis, depressor anguli oris,* and *orbicularis oris* muscle regions (see Cacioppo et al., 1990). To reduce subject awareness of the experimental hypotheses, subjects were told that the study concerned the natural 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. Before the experimental trials began, subjects relaxed for 10 min to allow general adaptation to the laboratory. Subjects were next instructed to examine each slide projected onto a screen 1.5 m in front of them and to answer questions posed after the presentation of each slide. Questions were posed on a 22.86-cm (9-in.) videomonitor suspended in front of the subject, and responses were made using a numeric keypad. Subjects were tested while seated alone in the subject's chamber.

All subjects viewed a block of 36 slides before receiving additional instructions about amplifying or inhibiting their facial reactions to the experimental stimuli. Several procedures were used to decrease the likelihood that subjects were aware that facial actions were of interest during the first block of trials: (a) Subjects were tested individually in a room adjacent to but isolated from the experimenter and equipment, (b) a cover story was used that focused on the operational procedures in the experiment and the abstract theoretical principles that were being examined in the study rather than on the type of response being measured, and (c) dummy as well as active electrodes were attached to the subject's face, head, and body to further deflect attention away from the face. In addition, the conditions in which subjects were instructed to control their facial expressions to the experimental stimuli, which were designed to extend previous research, were always introduced following the first block of trials to avoid any carryover that might occur once the experimenter instructed subjects to control (either to amplify or to inhibit) facial expressions to the visual stimuli. Instructions to amplify or inhibit their facial reactions to the experimental stimuli, however, were counterbalanced across subjects. Thus, subjects were unaware that facial activity was of interest until the additional experimental instructions were introduced following the first block of trials.

Each slide was presented for 5 s. After each presentation, subjects used 9-point scales to rate how pleasant they considered the depicted scene (1 = *very unpleasant,* 9 = *very pleasant*), how aroused it made them feel (1 = *very relaxing,* 9 = *very arousing*), and how familiar the scene appeared (1 = *very novel,* 9 = *very familiar*). A closed-loop baseline was employed such that the next slide was presented only after subjects had returned to basal levels of somatic activity and had maintained them for at least 5 s (McHugo & Lanzetta, 1983).

The first six slides presented in each block of trials consisted of two positive, two neutral, and two negative slides (three of these six were scenes and three were faces). These slides served as buffers to allow habituation. Immediately following these buffer slides, subjects were exposed to 30 experimental slides (10 positive, 10 neutral, and 10 unpleasant slides, half of which were scenes and half of which were faces). Subjects were not aware of the total number of trials or of the transition between the buffer and experimental trials. Only the data collected during the presentation of the experimental slides were recorded.

The procedures in the amplify and inhibit conditions were identical to those in the first block of trials except that subjects were instructed to control their facial reactions to the stimuli. Subjects in the *inhibit condition* were told:

> Next, pictures will again be presented, and you will be asked how likable, arousing, and novel each is. This time, however, your task is to look at each picture as it is presented *and control your face so that it does not indicate whether you like or dislike the picture.* For example, if a friend were to watch you when the picture was presented, your friend should be unable to determine what kind of picture was presented to you. *Remember: Keep your face void of all expressions when each picture is presented.*

In the *amplify condition,* subjects were told:

> Next, pictures will again be presented, and you will be asked how likable, arousing, and novel each is. This time, however, your task is to look at each picture as it is presented *and control your face so that it subtly indicates whether you like or dislike the picture.* For example, if a friend were to watch you when the picture was presented, your friend should be able to subtly determine what kind of picture was presented to you. *Remember: Use your face to subtly express the extent to which you like or dislike each picture.*

Instructions emphasized that subjects should *not* exhibit overt facial expressions, because we sought to keep the size of the EMG responses roughly equal (i.e., incipient) across conditions. For instance, subjects were told that if a stranger were sitting with a friend in front of them, neither the friend nor the stranger should know the affective nature of the slide presented (inhibit condition), or the friend but not the stranger should know the affective nature of the slide presented (amplify condition).

At the completion of the study, subjects were given a questionnaire concerning their interpretations of the experiment and their own hypothesis about the purpose of the study. Subjects were then debriefed, thanked, given laboratory credit, and asked not to disclose any aspects of the experiment with others in their class. No subject articulated the experimental hypothesis, and none expressed suspicion that her facial reactions to the slides shown in the first block of trials were a focus of study.

Data Reduction

Each channel of EMG was transmitted on-line to a laboratory computer, digitized at a resolution of 0.3 μV/unit and at a rate of 100 samples per second. In addition, during the study the rectified and smoothed EMG recordings were displayed on an oscillograph, raw EMG signals were intermittently checked using an oscilloscope, and subjects were monitored using a hidden video camera. Subsequently, data were deleted for trials on which artifacts or eyeblinks were detected or for which the response exceeded full-scale deflection (i.e., 80 μV).[4] Finally, EMG activity at each recording site and within each condition was averaged across trials to maximize measurement reliability.

RESULTS AND DISCUSSION

Because the counterbalanced instructional manipulations were introduced after the completion of the first block of trials, two sets of analyses were performed: (a) The data from the first block of 30 experimental trials were subjected to 2 (Stimulus Type) × 3 (Valence) repeated-measures analyses of variance, and (b) the data from the second and third blocks of experimental trials were subjected to 2 (Instruction) × 2 (Stimulus Type) × 3 (Valence) repeated-measures analyses of variance. Greenhouse-Geiser corrections were used, and significant tests were followed by pairwise comparisons.[5]

Effects of Viewing Pleasant, Neutral, and Unpleasant Slides of Scenes and People

Manipulation checks. Analyses of the subjects' ratings of pleasantness, arousal, and familiarity provided evidence for the efficacy of the experimental manipulations. Repeated-measures analyses of each stimulus rating revealed that pleasantness, $F(1.5, 23.2) = 114.02$, $p < .001$, reported arousal, $F(1.4, 22.5) = 17.57$, $p < .001$, and familiarity, $F(2, 32) = 37.89$, $p < .001$, varied as a function of valence. Cell means are summarized in Figure 1. Pairwise comparisons indicated that the positive stimuli were judged the most pleasant, relaxing, and familiar and the negative stimuli were rated as the least pleasant, relaxing, and familiar.

Facial EMG activity over the brow (corrugator supercilii), *cheek* (zygomaticus major), *and periocular* (orbicularis oculi) *muscle regions.* Repeated-measures analyses indicated that EMG activity over the brow muscle region, $F(2, 32) = 8.54$, $p < .01$, and periocular muscle region, $F(2, 32) = 5.81$, $p < .01$, varied as a function of valence. Cell means are summarized in Figure 1. Pairwise comparisons revealed that EMG activity over the brow region was diminished, and EMG activity over the periocular muscle region was elevated, when subjects viewed pleasant in contrast to neutral or unpleasant slides.

If the visual depiction of human faces in a scene is sufficient to activate a social motive, then the slides of social scenes, in contrast to nature scenes, should affect facial EMG responses. No evidence was found to support this hypothesis. Repeated-measures analyses revealed only one significant test involving stimulus type: EMG activity over the periocular muscle region was higher when subjects viewed nature scenes ($M = 7.16$) than social scenes ($M = 5.93$), $F(1, 16) = 20.90$, $p < .01$, and this effect did not vary across stimulus valence.

Facial EMG activity over the forehead (medial frontalis) *and perioral* (orbicularis oris) *muscle regions.* Repeated-measures analyses of variance failed to reveal any significant tests ($ps > .10$). These results indicate that the experimental conditions did not differ in general tension across the facial muscles. Cell means are summarized in Figure 1.

Summary. The results from the first part of the study generally replicated those reported by Cacioppo et al. (1986) and Dimberg (1982). Pleasant stimuli (both faces and scenes) were associated with lower EMG activity over the brow and higher EMG activity over the periocular region than unpleasant stimuli. Contrary to Dimberg (1982) but as in Cacioppo et al. (1986), EMG activity over the cheek muscle region did not differentiate the positive from the negative stimuli in this study. This result appears to be due to our selection of *weakly* evocative stimuli in our effort to avoid overt facial actions. In a recent experiment using a much wider range of pleasant and unpleasant pictures (e.g., a large tumor growing out of the eye socket of an infant; artistic depictions of nudes), Greenwald et al. (1989) found (a) a negative linear relationship between pleasantness ratings and EMG activity over the brow (*corrugator supercilii*) muscle region and (b) a positive quadratic relationship (J-shaped function) between pleasantness ratings and EMG activity over the cheek (*zygomaticus major*) muscle region. The J-shaped function was due to EMG activity over the cheek muscle region being modestly elevated during very unpleasant slide presentations, relatively inactive during mildly unpleasant to mildly pleasant slide presentations, and moderately to strongly activated during the very pleasant slide presentations. These data fit our own observations given that we restricted the experimental slides to those that were only mildly to moderately pleasant or unpleasant. This finding may help to explain some of the failures

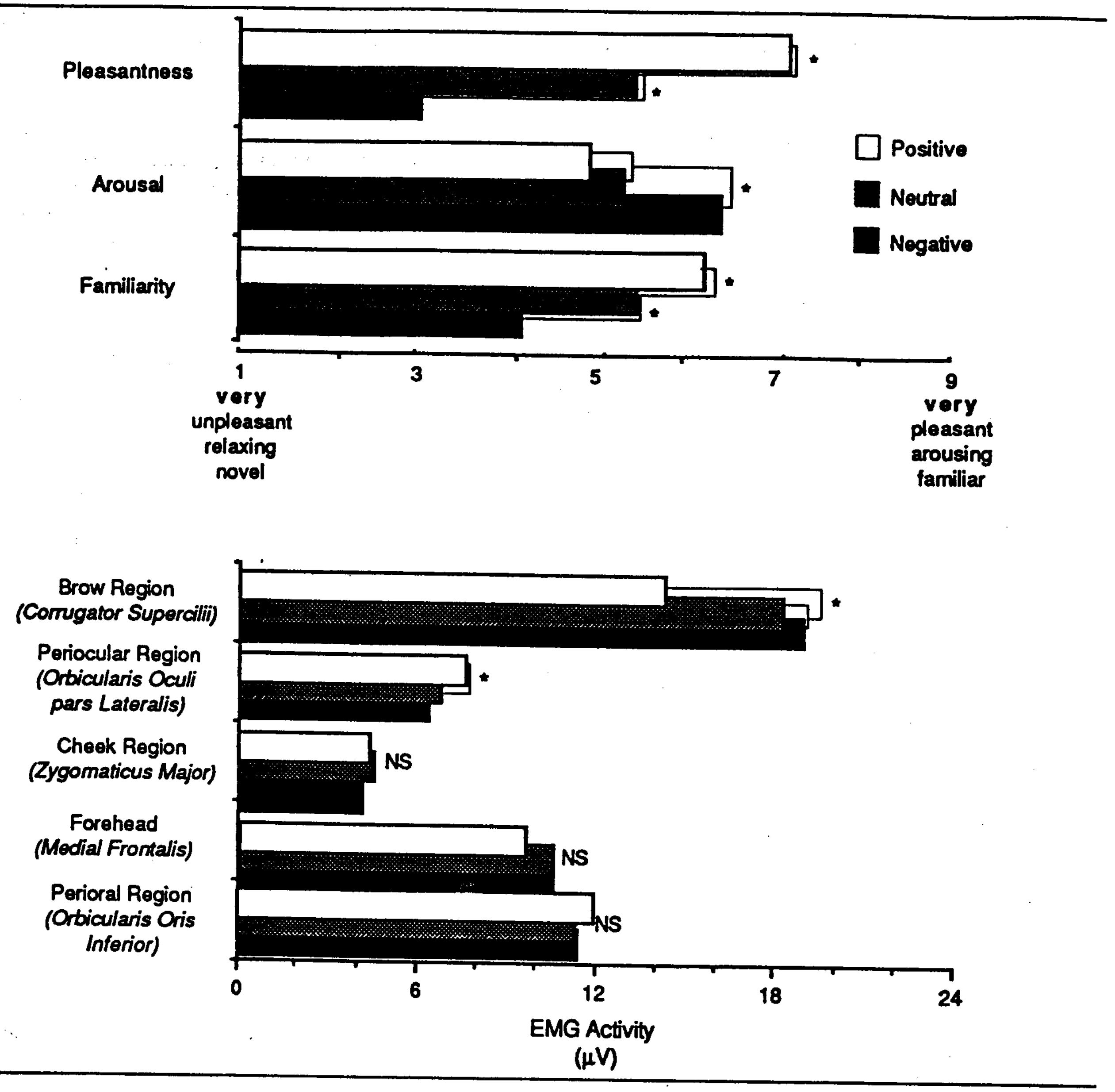

Figure 1. Mean ratings of slide presentations and mean amplitude of integrated electromyographic activity during slide presentations as a function of stimulus valence. Cell means marked by an asterisk differ by the Duncan multiple range test.

in the literature to find a significant relationship between EMG measures of smiling and subjects' affective experiences.

Effects of Instruction to Amplify or Inhibit Reactions to Pleasant, Neutral, and Unpleasant Slides of Scenes and People

Manipulation checks. Analyses of the subjects' ratings of pleasantness, arousal, and familiarity again provided evidence for the effectiveness of the experimental manipulations. Analyses revealed that pleasantness, $F(1.4, 21.8) = 220.25$, $p < .001$, familiarity, $F(2, 32) = 59.07$, $p < .001$, and arousal, $F(1.2, 19.2) = 17.94$, $p < .001$, varied as a function of valence. Pairwise comparisons, which are summarized in Figure 2, indicated that the positive stimuli were judged the most pleasant, relaxing, and familiar and the negative stimuli were rated as the least pleasant, relaxing, and familiar.[6]

Facial EMG activity over the brow (corrugator supercilii), *cheek* (zygomaticus major), *and periocular* (orbicularis oculi) *muscle regions.* Repeated-measures analyses confirmed significant instruction effects for EMG activity over the brow, $F(1, 16) = 6.34$, periocular, $F(1, 16) = 31.05$, and cheek, $F(1, 16) = 15.10$, muscle regions, all $ps < .001$. Not surprisingly, EMG activity over each muscle region was higher under amplify than inhibit instructions (see Figure 2).

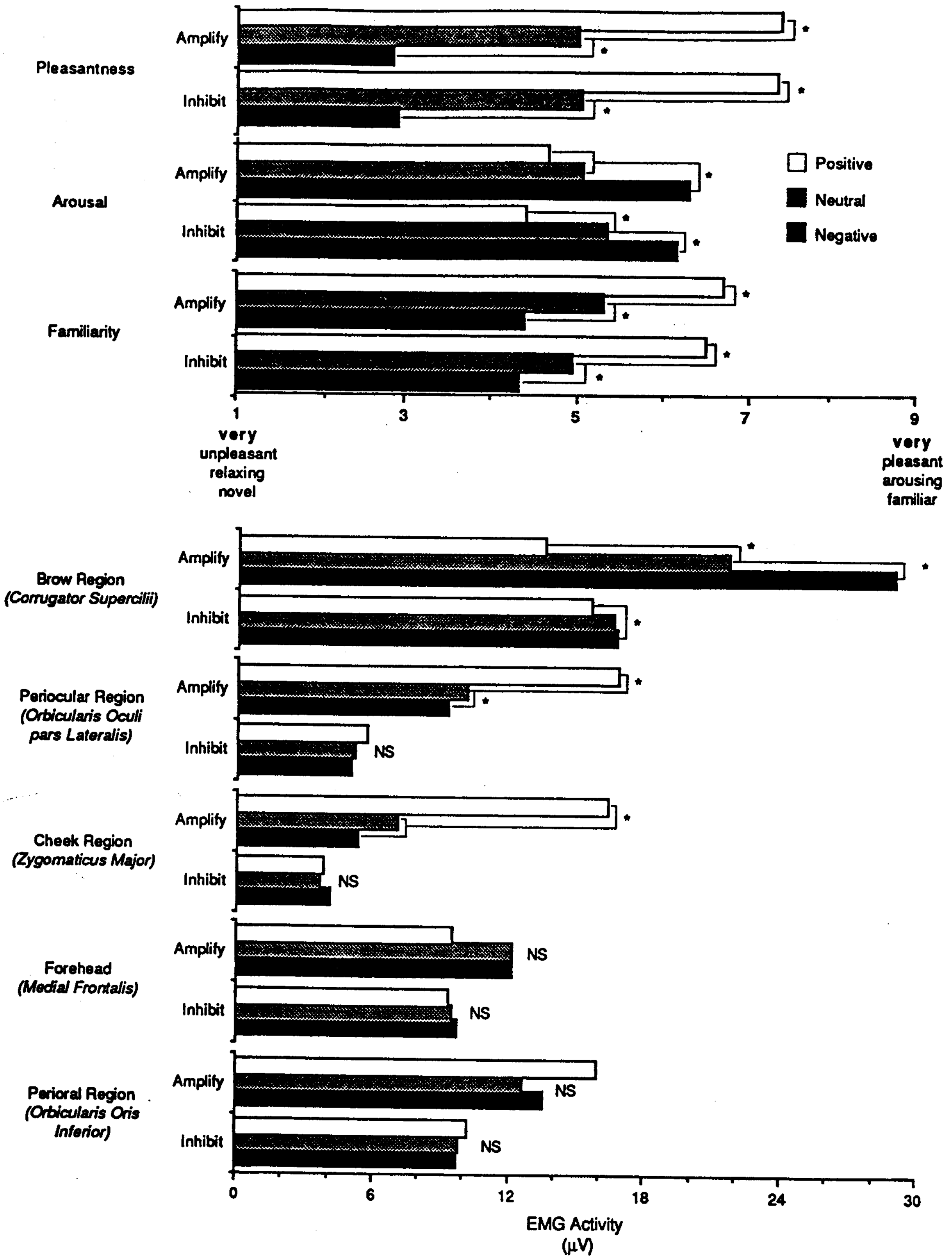

Figure 2. Mean ratings of slide presentations and mean amplitude of integrated electromyographic activity during slide presentations as a function of stimulus valence. Cell means within instructional conditions marked by an asterisk differ by the Duncan multiple range test.

More interestingly, the repeated-measures analyses indicated that EMG activity over the brow muscle region was lower, $F(1.2, 19.2) = 19.03$, and EMG activity over the periocular, $F(1.3, 21.3) = 11.05$, and cheek, $F(1.2, 18.5) = 19.82$, muscle regions was higher when subjects viewed relatively pleasant slides, all ps $< .001$. In addition, significant interactions were found for EMG activity over the brow, $F(1.1, 18.2) = 18.11$, $p < .001$, periocular, $F(1.3, 21) = 9.32$, $p < .01$, and cheek muscle regions, $F(1.2, 18.8) = 18.06$, $p < .001$. These interactions were decomposed using pairwise comparisons within the amplify and the inhibit conditions. The cell means and tests are summarized in Figure 2. In the amplify condition, EMG activity was lower over the brow muscle region and higher over the cheek and periocular muscle regions when subjects viewed relatively pleasant slides. In the inhibit condition, however, only one pairwise comparison was statistically significant: EMG activity over the brow muscle region was lower when subjects viewed pleasant, in contrast to neutral or unpleasant, stimuli (see Figure 2). In sum, facial EMG activity varied as a function of valence but was again comparable across stimulus type (social vs. nature scenes) when these stimuli were matched for pleasantness.

Facial EMG activity over the forehead (medial frontalis) *and perioral* (orbicularis oris) *muscle regions.* No repeated-measures test nor any pairwise comparison was significant (ps $> .10$, see Figure 2). Thus, although EMG activity over the forehead muscle region has occasionally been found to be higher in response to unpleasant than pleasant tasks (e.g., Brown & Schwartz, 1980), this effect has not been robust when mildly evocative stimuli have been used (e.g., see Figure 2; Cacioppo et al., 1986).

TABLE 1: Effect Sizes for Valence Within Instruction Conditions

Measure	*Eta*	*Effect Size*
Brow (*corrugator supercilii*) region		
No instruction	.59	.73
Amplify	.74	1.09
Inhibit	.46	.52
Periocular (*orbicularis oculi*) region		
No instruction	.52	.60
Amplify	.63	.81
Inhibit	.36	.38
Cheek (*zygomaticus major*) region		
No instruction	.18	.18
Amplify	.74	1.11
Inhibit	.18	.18
Forehead (*medial frontalis*) region		
No instruction	.40	.43
Amplify	.39	.42
Inhibit	.21	.21
Perioral (*orbicularis oris*) region		
No instruction	.14	.14
Amplify	.30	.31
Inhibit	.11	.11

Effect sizes for valence across facial muscle regions. The preceding analyses indicated that the most consistent determinant of facial EMG activity was stimulus valence. Analyses also suggested that EMG activity over the brow muscle region varied most consistently as a function of valence. To supplement these observations regarding the strength of the valence effect across muscle regions, we calculated the effect sizes for valence within each condition for each muscle region. Inspection of Table 1 reveals three interesting results in light of the analyses reported above: (a) The effect size for valence was strongest in the amplify condition and weakest in the inhibit condition; (b) the effect sizes were highest for EMG activity over the brow and periocular muscle regions; and (c) the difference between the effect sizes for valence found when subjects were instructed to amplify versus inhibit expressions of emotion was maximal for EMG reactions measured over the cheek muscle region. These results are consistent with prior research (e.g., Ekman et al., 1988) in suggesting that facial expressions displayed for communicative purposes (e.g., polite or social smiling) may be more evident over the muscles of the middle or lower face (e.g., *zygomaticus major* (muscle region) than over the muscles of the upper face (e.g., *corrugator supercilii* muscle region).

Summary. The clear and obvious effect of instruction on facial EMG activity over the brow, periocular, and cheek muscle regions is compatible with the notion that one function of facial efference is to modulate social and communicative processes. Of course, this result does not speak to whether these facial expressive movements are involved *spontaneously* in social communication but only shows that they have the potential to serve a communicative function. The significant effects found for valence (even in the inhibit-expression condition) and the absence of any interactions involving stimulus type, however, appear more compatible with the notion that facial efference is determined by people's affective appraisals of events than with the notion that facial efference is unrelated to affect and serves *only* a communicative function. Thus, facial EMG activity is perhaps best conceived as a multiply determined psychophysiological event (i.e., a psychophysiological outcome rather than a psychophysiological index; see Cacioppo & Tassinary, 1990).

Even though we focused on facial muscles in this study, our interpretation of these data is not limited to the expressive movements of the facial muscles. As Darwin (1873) suggested, "Movements or changes in any part of the body,—as the wagging of a dog's tail, the drawing back of a horse's ears, the shrugging of a man's shoulders, or the dilation of the capillary vessels of the skin—may all equally well serve for expression" (p. 28). To illustrate, imagine a study in which subjects who were induced to wait impatiently were found to tap their foot and toes. (Indeed, these subjects might be found to tap their toes when they were induced to wait impatiently even though they might be unaware of doing so.) In this hypothetical study, big-toe activity would vary as a function of the subjects' feelings of impatience. Even if toe-tapping during impatience had developed as a social signal, as if one were publicly timing the tardiness of a conspecific, a strong association has been forged between the outward expression and the psychological state, and this association persists even when no communicative purpose is served by the expression. Of course, the subjects in this hypothetical study could likely alter the tapping of their toes when instructed to amplify or inhibit their gestures reflecting how they felt about waiting, and data of this type would indicate that movements of the big toe *could* be used for communication purposes. That is, people could tap their toes to display impatience (i.e., as a social signal) whether or not they actually felt impatient. Thus, toe-tapping, like facial expressions of emotion, can be associated with or disassociated from social motives and affective states. This is precisely the result one would expect if expressive movements were multiply determined events.

GENERAL DISCUSSION

The study of emotional expressions has contributed to advances in theories and research on emotion. For instance, emotional expressions have been used to generate emotions (Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, & Friesen, 1990) and to mark when emotion is aroused, and what emotion is aroused, by internal (e.g., Ekman et al., 1983) and external stimuli (e.g., Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Ekman, Davidson, & Friesen, 1990). Important questions remain, however, about the relation of facial expressions to emotional stimuli. What is the evolutionary basis for emotional expressions, what are the antecedent conditions for expressions of emotion, and under what conditions are emotions and "expressions of emotion" uncoupled? Recent attempts to answer the first of these questions have emphasized the interpersonal (e.g., social communicative, social regulatory) currency of emotional expressions throughout evolution (e.g., Fridlund, 1990; Jones et al., 1991). These attempts have also led to tentative answers to the second two questions: "By this view, human facial expressions are first and foremost evolved social displays—the tools of specific social motives. Like the behavioral displays of other animals, our facial movements encode information about our behavioral tendencies, not our emotional states" (Jones et al., 1991, p. 45).

Data from the present study suggest that facial expressions have no *necessary* relation to affective experience. For instance, instructions to adopt a particular communicative intent influenced facial EMG responses even though subjects' affective reports were unchanged. Several other features of the results, however, favor the hypothesis that facial expressions are not solely determined by social motives. In the first block of 30 experimental trials, subjects privately viewed slides of pleasant, neutral, or unpleasant nature and social scenes. Results replicated previous research demonstrating that facial EMG activity (particularly over the *corrugator supercilii* muscle region) varied as a function of the pleasantness of visual stimuli. In addition, facial EMG activity was similar whether subjects were exposed to slides of nature scenes or social scenes that were matched for rated pleasantness.

Prior to the second and third blocks of 30 trials, subjects were instructed to deliberately control subtle facial expressive movements to communicate the affective valence of each stimulus (amplify-expression condition) or to deliberately inhibit any facial reaction that might signal the affective valence of each stimulus (inhibit-expression condition). Results revealed the expected finding that the amplitude of facial electromyographic activity was higher in the amplify than the inhibit condition, but results also revealed that electromyographic activity over the brow (*corrugator supercilii*) muscle region varied as a function of the affective valence of the stimuli even when subjects were instructed to inhibit any display of emotion. Facial electromyographic activity again did not differ when subjects were exposed to slides of nature scenes or social scenes. These results are consistent with the notion that facial efference, even when too subtle to produce a socially perceptible facial expression, can be altered by both affective and communicative processes, but they also suggest that viewing pictures of people is not sufficient to elicit a stronger social motive than viewing nature scenes.

Ekman and Friesen (1982) speculated that the facial action that produced smiling had no necessary association with emotional experience; instead, they suggested that an association between smiling and emotional experience would be evident when the smiling was accompanied by the appearance of crow's-feet at the outer edge of the eyes. Rinn (1984) reviews evidence of differences in the innervation of the muscles of the upper and lower face and indicates that some features of movement are simpler to control in the muscles of the lower than the upper face. In the present study, we found that EMG activity over the brow and periocular muscle regions varied as a function of the pleasantness of the stimulus (see Figures 1 and 2). We also found that the effect sizes for the instructional manipulation was larger for muscles of the lower and middle face than those in the brow region (see Table 1). These effects are relative, however. Inspection of Figure 2 reveals that subjects were able to inhibit expressive facial actions involving the muscles in the cheek *and* the periocular regions when they were instructed to hide their affective reaction to the slide presentation. EMG activity over the brow muscle region was also attenuated when subjects attempted to inhibit the expression of their feelings, but only EMG activity over the brow region varied significantly as a function of stimulus valence (see Figure 2). Interestingly, this latter effect was not due to activation of the muscles of the brow region when unpleasant stimuli were viewed; instead, it was due to subjects' failure to disinhibit muscular activity in the brow region when pleasant stimuli were viewed. Nevertheless, people appear to be more capable of dampening expressive facial actions (e.g., even microexpressive actions over the *orbicularis oculi* region) than had previously been thought.

This study raises four caveats about research on the psychological significance of facial expressions. First, our results are consistent with a growing body of research indicating that the facial muscles of the lower and middle regions are relatively simple to inhibit or control when one views affective stimuli. These findings raise concerns about the generality of research on the importance or impact of social motives in which smiling is the sole focus. This is not to say that smiling behavior should not be measured. Given the suggestion from the present results that even covert facial actions are multiply determined, the measurement of facial EMG activity from multiple sites may have an important role to play in parsing apart the psychological processes underlying a change in EMG activity at any one or two sites. Second, results from this experiment replicated results from several laboratories showing that facial EMG activity can vary as a function of affective stimuli even though these muscular actions are insufficient in intensity to manifest as overt facial expressions. Thus, observational studies that fail to find observable facial expressions to emotional stimuli (e.g., Graham, 1980; Jones et al., 1991; Kraut & Johnston, 1979) may be overlooking subtler, microexpressive actions in emotion. Third, to the extent that facial muscular actions are subject to multiple determinants, the utility of these actions for indexing any one of these determinants (e.g., affective reaction, social motive) may be diminished. Finally, some proponents of the view that facial expressions vary as a function of social motives (but not emotions) may wish to dispute the importance we place on people's emotional experience in explaining some of our data. If these data lead to specification of the conditions under which implicit audiences are or are not invoked by solitary individuals, and the conditions in which implicit audiences enhance, diminish, or leave unchanged the frequency and strength of facial displays of emotion, then these data will have advanced research on facial expressions and on emotion.

NOTES

1. This is not to suggest that subjects in Dimberg's (1982) study were trying to communicate to a still face but, rather, that viewing pictures of human faces displaying smiles and anger in an experiment on "the physiological reactions to different types of stimuli" (Dimberg, 1982, p. 644) may be sufficient to prime a congruent social motive. For instance, priming of this sort could result from a lifetime of experience of viewing human expressions during social interactions (e.g., classical conditioning), or it might reflect a biologically prepared response.

2. Women were recruited to serve as subjects to minimize the error variance attributable to sex differences (e.g., regarding what visual stimuli are pleasant versus neutral) and to maintain same-sex conditions between subjects and experimenter.

3. For information on the psychometric properties of electromyographic recordings over these muscle regions, see Tassinary, Cacioppo, and Geen (1989) and Tassinary, Cacioppo, Geen, and Vanman (1987). Electromyographic activity over the *depressor anguli oris* muscle region was also monitored in this study, but our subsequent research on the reliability and validity of surface recordings of electromyographic activity over the *depressor anguli oris* muscle region revealed poor psychometric properties for this measure. Hence, although the expected results were found in the present recordings of electromyographic activity over the *depressor anguli oris* region (e.g., greater activity in the amplify than the inhibit condition; greater activity in response to positive or negative than neutral stimuli), the psychometric properties of this measure are of sufficient concern to us that we do not discuss this measure further.

4. Although subjects generally complied with the instructions to avoid exhibiting overt facial expressions, there were exceptions, particularly in the amplify condition. The calibration of the preamplifiers was such that clearly overt facial actions attributable to the *corrugator supercilii*, *orbicularis oculi*, *zygomaticus major* or *medial frontalis* muscles would yield off-scale EMG responses. Data from three subjects were deleted prior to analyses because of off-scale responses over the *zygomaticus major* muscle region. Although data on other measures were available from these subjects, we adopted the more conservative strategy of excluding all data from these subjects in the analyses reported in the Results and Discussion section. In no case were the results changed by the inclusion of available data from these additional three subjects.

5. Preliminary MANOVAs were conducted treating order as an additional between-subjects factor. Only one significant effect was found: a main effect for order that was attributable to subjects rating the first block of experimental stimuli more arousing in one than another order. Importantly, this main effect did not qualify any of the effects reported in the text, and the test for this main effect was not significant in the analyses of the second and third blocks of data. Therefore, it is not discussed further. Finally, the statistical significance of the pairwise comparisons for facial EMG activity was evaluated against an α level of $p < .05$, one-tailed, because these tests represented conceptual replications (spontaneous conditions) and extensions (amplify and inhibit conditions) of Cacioppo, Petty, Losch, and Kim (1986) and Dimberg (1982).

6. Two additional multivariate tests were significant: the two-way interaction of Valence × Stimulus Type, $F(6, 11) = 5.58$, and the three-way interaction of Valence × Stimulus Type × Instruction, $F(6, 11) = 3.18$. Repeated-measures analyses indicated a Valence × Stimulus Type interaction on the measures of pleasantness, $F(2, 32) = 11.74$, and

arousal, $F(2, 32) = 3.48$, and a Valence × Stimulus Type × Instruction interaction on the measure of pleasantness, $F(2, 32) = 3.22$. Briefly, the instructions to amplify or inhibit facial expressive movements tended to have a stronger effect on verbal ratings following slides of negative than neutral or positive nature scenes, and this difference was slightly larger in response to nature than social scenes. These differences were small, however, and none of the pairwise comparisons within levels of valence were statistically significant. Because these differences were small and do not bear on the experimental hypotheses, they are not discussed further.

REFERENCES

Brown, S. L., & Schwartz, G. E. (1980). Relationships between facial electromyography and subjective experience during affective imagery. *Biological Psychology, 11*, 49-62.

Bush, L. K., Barr, C. L., McHugo, G. J., & Lanzetta, J. T. (1989). The effects of facial control and facial mimicry on subjective reactions to comedy routines. *Motivation and Emotion, 13*, 31-52.

Cacioppo, J. T., Martzke, J. S., Petty, R. E., & Tassinary, L. G. (1988). Specific forms of facial EMG response index emotions during an interview: From Darwin to the continuous flow hypothesis of affect-laden information processing. *Journal of Personality and Social Psychology, 54*, 592-604.

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. *Journal of Personality and Social Psychology, 50*, 260-268.

Cacioppo, J. T., Petty, R. E., & Marshall-Goodell, B. S. (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., & Tassinary, L. G. (1990). Inferring psychological significance from physiological signals. *American Psychologist, 45*, 16-28.

Cacioppo, J. T., Tassinary, L. G., & Fridlund, A. J. (1990). Skeletomotor system. In J. T. Cacioppo & L. G. Tassinary (Eds.), *Principles of psychophysiology: Physical, social, and inferential elements* (pp. 325-384). New York: Cambridge University Press.

Darwin, C. (1873). *The expression of the emotions in man and animals.* New York: D. Appleton.

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

Dimberg, U. (1982). Facial reactions to facial expressions. *Psychophysiology, 19*, 643-647.

Dimberg, U. (1986). Facial reactions to fear-relevant and fear-irrelevant stimuli. *Biological Psychology, 23*, 153-161.

Dimberg, U. (1988). Facial electromyography and the experience of emotion. *Journal of Psychophysiology, 2*, 277-282.

Dimberg, U., & Thell, S. (1988). Facial electromyography, fear relevance, and the experience of stimuli. *Journal of Psychophysiology, 2*, 213-220.

Ekman, P. (1971). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska Symposium on Motivation* (Vol. 19, pp. 207-283). Lincoln: University of Nebraska Press.

Ekman, P. (1977). Biological and cultural contributions to body and facial movement. In J. Blacking (Ed.), *The anthropology of the body* (pp. 39-84). London: Academic Press.

Ekman, P. (1979). About brows: Emotional and conversational signals. In J. Aschoff, M. von Carnach, K. Foppa, W. Lepenies, & D. Plog (Eds.), *Human ethology* (pp. 169-202). Cambridge: Cambridge University Press.

Ekman, P. (1989). The argument and evidence about universals in facial expressions of emotion. In H. Wagner & A. Manstead (Eds.), *Handbook of social psychophysiology* (pp. 143-164). Chichester, England: Wiley.

Ekman, P. (1992). Are there basic emotions? A reply to Ortony and Turner. *Psychological Review, 99*, 550-553.

Ekman, P., Davidson, R. J., & Friesen, W. V. (1990). Duchenne's smile: Emotional expression and brain physiology II. *Journal of Personality and Social Psychology, 58*, 342-353.

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

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

Ekman, P., Levenson, R. W., & Friesen, W. V. (1983). Autonomic nervous system activity distinguishes among emotions. *Science, 221*, 1208-1210.

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

Fridlund, A. J. (1990). Evolution and facial action in reflex, social motive, and paralanguage. In P. K. Ackles, J. R. Jennings, & M.G.H. Coles (Eds.), *Advances in psychophysiology* (Vol. 4). Greenwich, CT: JAI.

Fridlund, A. J. (1991). Sociality and solitary smiling: Potentiation by an implicit audience. *Journal of Personality and Social Psychology, 60*, 229-240.

Fridlund, A. J., & Cacioppo, J. T. (1986). Guidelines for human electromyographic research. *Psychophysiology, 23*, 567-589.

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

Greenwald, M. K., Cook, E. W., III, & Lang, P. J. (1989). Affective judgment and psychophysiological response: Dimensional covariation in the evaluation of pictorial stimuli. *Journal of Psychophysiology, 3*, 51-64.

Hager, J. C., & Ekman, P. (1983). The inner and outer meanings of facial expressions. In J. T. Cacioppo & R. E. Petty (Eds.), *Social psychophysiology: A sourcebook* (pp. 287-306). New York: Guilford.

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

Izard, C. E. (1977). *Human emotions.* Orlando, FL: Academic Press.

Izard, C. E. (1990). Facial expressions and the regulation of emotions. *Journal of Personality and Social Psychology, 58*, 487-498.

Izard, C. E. (1992). Basic emotions, relations among emotions, and emotion-cognition relations. *Psychological Review, 99*, 561-565.

Izard, C. E., & Malatesta, C. Z. (1987). Perspectives on emotional development I: Differential emotions theory of early emotional development. In J. Osofsky (Ed.), *Handbook of infant development.* New York: Wiley-Interscience.

Jones, S. S., Collins, K., & Hong, H. (1991). An audience effect on smile production in 10-month-old infants. *Psychological Science, 2*, 45-49.

Kraut, R. E., & Johnston, R. E. (1979). Social and emotional messages of smiling: An ethological approach. *Journal of Personality and Social Psychology, 37*, 1539-1553.

Levenson, R. W., Ekman, P., & Friesen, W. V. (1990). Voluntary facial action generates emotion-specific autonomic nervous system activity. *Psychophysiology, 27*, 363-384.

McCanne, T. R., & Anderson, J. A. (1987). Emotional responding following experimental manipulation of facial electromyographic activity. *Journal of Personality and Social Psychology, 52*, 759-768.

McHugo, G. J., & 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.

McHugo, G. J., Lanzetta, J. T., & Bush, L. K. (in press). The effect of attitude on emotional reactions to expressive displays of political leaders. *Journal of Nonverbal Behavior.*

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. *Journal of Personality and Social Psychology, 49*, 1513-1529.

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

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*, 489-491.

Sumitsuji, N., Nan'no, H., Kuwata, Y., & Ohta, Y. (1980). The effects of the noise due to the jet airplane to the human facial expression (EMG study), EEG change and their manual responses at the various sleeping stages of the subjects. *Electromyography and Clinical Neurophysiology, 20,* 49-72.

Tassinary, L. G., Cacioppo, J. T., & Geen, T. R. (1989). A psychometric study of surface electrode placements for facial electromyographic recording: I. The brow and cheek muscle regions. *Psychophysiology, 26,* 1-16.

Tassinary, L. G., Cacioppo, J. T., Geen, T. R., & Vanman, E. (1987). Optimizing surface electrode placements for facial EMG recordings: Guidelines for recording from the perioral muscle region. *Psychophysiology, 24,* 615-616.

Teasdale, J. D., & Rezin, V. (1978). Effect of thought-stopping on thoughts, mood, and corrugator EMG in depressed patients. *Behaviour Research and Therapy, 16,* 97-102.

Received March 27, 1991
Revision received August 6, 1991
Accepted August 19, 1991