Emotion
2002, Vol. 2, No. 1, 52–74

1528-3542/02/$5.00 DOI: 10.1037//1528-3542.2.1.52

Duchenne Smile, Emotional Experience, and Autonomic Reactivity: A Test of the Facial Feedback Hypothesis

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This study examined the modulatory function of Duchenne and non-Duchenne smiles on subjective and autonomic components of emotion. Participants were asked to hold a pencil in their mouth to either facilitate or inhibit smiles and were not instructed to contract specific muscles. Five conditions—namely lips pressing, low-level non-Duchenne smiling, high-level non-Duchenne smiling, Duchenne smiling, and control—were produced while participants watched videoclips that were evocative of positive or negative affect. Participants who displayed Duchenne smiles reported more positive experience when pleasant scenes and humorous cartoons were presented. Furthermore, they tended to exhibit different patterns of autonomic arousal when viewing positive scenes. These results support the facial feedback hypothesis and suggest that facial feedback has more powerful effects when facial configurations represent valid analogs of basic emotional expressions.

The human face has long been recognized as a powerful signaling system serving both inter- and intraindividual regulatory functions. Implicit in such a view is the assumption that facial behavior constitutes not only the expressive output of inner emotional states or social motives but also an input to the subjective experience of emotion. The idea that afferent feedback from expressive behavior may play a causal role in the experience of emotion takes its roots in part from Charles Darwin's and William James's statements. Darwin (1872/1965) claimed that the intensity of emotional experience could be regulated by enhancing or inhibiting the expression, whereas James (1890) proposed that subjective feeling was the result of peripheral bodily changes (i.e., visceral and striated muscle activity) that directly follow the perception of the eliciting event. The influence of these views can be seen in more recent theories of emotion, which assign to facial expression a primary role in the subjective experience of emotion (Izard, 1971; Tomkins, 1962). This gave rise to the so-called facial feedback hypothesis (FFH), which stated that facial movement could influence emotional experience (Tourangeau & Ellsworth, 1979).

In the course of empirical investigation of the FFH, several variants of this hypothesis have been distinguished. First, Tourangeau and Ellsworth (1979) raised three questions derived from the FFH: (a) Is an appropriate facial expression necessary for the subjective experience of emotion? (necessity hypothesis); (b) Is a facial expression sufficient to produce an emotional experience, even in the absence of an evocative event? (sufficiency hypothesis); and (c) Does the strength of a facial expression covary positively with the intensity of emotional experience? (monotonicity hypothesis). Whereas the view that facial displays are necessary for experiencing emotion has not been supported (e.g., Fernández-Dols & Ruiz-Belda, 1995; Hess, Kappas, McHugo, Lanzetta, & Kleck, 1992), there is substantial evidence in favor of the sufficiency and monotonicity hypotheses (see Hess et al., 1992; McIntosh, 1996).

Although the several variants of the FFH do not necessarily imply causality between face and emotion, they all postulate that facial action can initiate (sufficiency hypothesis) and/or modulate the subjective experience of emotion (Adelmann & Zajonc, 1989; McIntosh, 1996). The initiation hypothesis

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I thank Nathalie Fontaine for her assistance in the data collection. I am grateful to Patrick Mollaret for helpful comments concerning the design of this research. I also thank Paul Gendreau, Benoist Schaal, and Rita Compatangelo for valuable comments on an earlier version of this article.

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states that affective experience can be generated by facial displays, even in the absence of an emotional stimulus. The modulation hypothesis, as postulated by Darwin, simply stipulates that facial displays (e.g., intensifying or inhibiting a facial expression) may alter the intensity or the quality of the ongoing emotional experience.

An additional distinction between dimensional and categorical versions of the FFH has been suggested (Winton, 1986). According to the so-called weak version, facial movements may produce changes in self-reports of emotional experience on a positive–negative dimension. According to the so-called strong version, movements of the face may foster more differentiated emotional experience, such as enjoyment, anger, fear, and sadness.

The distinct versions and variants of the FFH typically have been tested by manipulating facial efference by means of two paradigms: (a) by asking participants to display facial configurations that represent particular emotional expressions (i.e., facial-posing procedure/muscle-by-muscle instruction) with or without an emotional stimulus (Duclos et al., 1989; Hess et al., 1992; Laird, 1974; Rutledge & Hupka, 1985; Tourangeau & Ellsworth, 1979); (b) by asking participants to exaggerate or suppress facial displays (exaggeration/suppression procedure) normally expected in response to a wide range of affective–eliciting events, such as electric shocks, videotapes, odors, or mental imagery (Colby, Lanzetta, & Kleck, 1977; Kleck et al., 1976; Kraut, 1982; Lanzetta, Cartwright-Smith, & Kleck, 1976; McCanne & Anderson, 1987; Zuckerman, Klorman, Larrance, & Spiegel, 1981).

Numerous experimental investigations focusing on the modulating function of facial expression within a dimensional perspective have generally demonstrated moderate but reliable effects of voluntary facial activity on self-reported emotional experience and, to some extent, on autonomic response patterns (for reviews see Adelmann & Zajonc, 1989; Laird, 1984; Manstead, 1988; Matsumoto, 1987; McIntosh, 1996; Winton, 1986). Concerning the categorical version of FFH, despite some contradictory findings (Tourangeau & Ellsworth, 1979), evidence has now accumulated suggesting that adopting a requested facial pattern of emotion (e.g., fear, anger, disgust, sadness, happiness) may induce a feeling of this particular emotion, even in the absence of any eliciting event. (Duclos et al., 1989; Duclos & Laird, 2001; Flack, Laird, & Cavallaro, 1999; Hess et al., 1992; Levenson, Ekman, & Friesen, 1990; Levenson, Ekman, Heider, & Friesen, 1992). Finally, although the issue of autonomic differentiation within the categorical version of FFH has provided a lower degree of consistency (see Boiten, 1996; Cacioppo, Klein, Berntson, & Hatfield, 1993), muscle-by-muscle manipulation or posing a particular facial expression have been shown to induce changes in heart rate, electrodermal activity, and peripheral temperature (Ekman, Levenson, & Friesen, 1983; Hess et al., 1992; Levenson et al., 1990, 1992).

Because of a number of methodological problems, the cognitive and physiological mechanisms underlying the facial regulation of affective states are far from being understood (Buck, 1980; Larsen, Kasimatis, & Frey, 1992; Strack, Martin, & Stepper, 1988; Zajonc, Murphy, & Inglehart, 1989). Some authors have suggested that sensory input (i.e., muscular proprioceptive patterns and/or cutaneous sensations) or vascular changes (i.e., thermoregulation of cerebral arterial blood flow) are possible physiological mediators (Izard, 1990; McIntosh, Zajonc, Vig, & Emerick, 1997; Tomkins, 1962; Zajonc et al., 1989). Others have postulated that feeling states may derive from the self-perception of expressive behavior and that individuals may have the ability to interpret their muscular proprioceptive sensation as representative of their subjective experience (Laird, 1974).

Strack et al. (1988) pointed out that standard procedures of experimenter-manipulated expressions (i.e., facial posing and dissimulation/exaggeration paradigms) do not rule out ambiguities and experimental artifacts due to situational demands (see also Rutledge & Hupka, 1985). In particular, these authors argued that these procedures are possibly contaminated by a cognitive mediation (e.g., attribution processes, redirection of attention, recognition of the emotional meaning of facial behavior, category accessibility), thus making difficult to assess the possibility of physiologically driven mechanisms. To clarify the processes that mediate the facial feedback effect, an ingenious procedure minimizing the likelihood that participants make inferences about their subjective experience of emotion was designed. According to this procedure participants (a) did not have to pose or modify a required facial expression, (b) redirected their attention toward another task, and (c) activated only the muscles typically involved in an expression. A plausible cover story was used to distract the participants' attention toward their own facial displays. The participants were told that the objective of the study was to investigate the ability of injured or handicapped persons to perform different tasks with different parts of their body. Specifically, in Study 1, they were instructed to hold a pen in their teeth (facilitating the production of smiling because of the contraction of zygomaticus major muscle), in their lips (inhibiting the smile because of the contraction of orbicularis oris muscle), or in their nondominant hand, while they rated the funniness of cartoons. In Study 2, they were asked to differentiate between the funniness of the cartoons and the amusement feeling induced by them. Using task difficulty as a covariate, the authors found that the unconscious facilitation of smiling behavior led the participants to rate the cartoons as being funnier, whereas inhibiting the muscular activity associated with smiling dampened their funniness ratings (Study 1). Furthermore, when participants were given the opportunity to distinguish between the two measures of the humor response, a facial feedback effect was reported for the amusement ratings only (Study 2). From these results, the authors concluded that cognitive mediation (i.e., self-perception process and recognition of the emotional meaning of facial expressions) is not necessary to influence the experience of emotion.

Because of a variety of methodological limitations, the research conducted by Strack et al. (1988) is not entirely conclusive. First, it is unclear whether the facilitating influence of smiling on emotional experience specifically was due to facial muscle feedback. Indeed, the authors did not examine whether their pen-holding conditions were related to differences in pleasantness of the task. Thus, this leaves open the possibility that the funniness ratings of the cartoons (Study 1) or the amusement ratings (Study 2) they evoked may have been contaminated by differences of affective conditions between the pen-holding techniques.

A second problem with Strack et al.'s (1988) research concerns the definition of their facial control condition (i.e., holding the pen with lips induces lips pressing). This condition causes the contraction of a muscle (i.e., orbicularis oris) involved in the expression of anger (Ekman & Friesen, 1975; Ekman, Friesen, & O'Sullivan, 1988). Accordingly, the question arises as to whether differences in amusement ratings detected in their study were not contaminated by the potentially negative effect of the orbicularis oris activity. An adequate facial control for testing the specific effect of smiling on positive affect would be to use a neutral face or a face without the presence of muscle action associated with a negative emotion.

Another limitation of Strack et al.'s (1988) studies concerns the choice of criteria used to represent the requested facial expression. This requires that the experimenter-manipulated facial expression (a) recruits only patterns of facial muscles reported from the empirical research on basic emotions, (b) meets certain criteria with regard to intensity and duration of muscular actions, and (c) does not contain extraneous muscle movements generated by the presence of emotional stimuli (Hager & Ekman, 1981; Matsumoto, 1987). In their studies, the lack of recording and measurement of actual facial behavior while participants were exposed to cartoons raises questions about the comparability of participants' data, both across and within pen-holding tasks. More particularly, because facial expression may change as a function of a number of parameters (e.g., intensity, duration, recruitment of additional actions), it appears important to verify that the muscular movements produced are exactly the same as those requested.

Finally, regarding the issue of the quality of smiling, Strack et al.'s (1988) studies focused only on the manipulation of zygomatic major action, whereas research findings highlighted that distinguishing among morphologically different types of smiles may be heuristically relevant (Dickson, Walker, & Fogel, 1997; Ekman, Davidson, & Friesen, 1990; Ekman et al., 1988; Fox & Davidson, 1988; Messinger, Fogel, & Dickson, 2001; Soussignan & Schaal, 1996b). More particularly, a distinction has been made between the basic smile, which recruits only zygomaticus major muscles, and the Duchenne smile, which involves the simultaneous activation of zygomaticus major and orbicularis oculi. The latter muscles raise the cheeks and wrinkle the outside corners of eyes (Duchenne, 1862/1990; Ekman, 1989). Because smiles with Duchenne's marker (i.e., the presence of orbicularis oculi activity) have been more often associated with the experience of positive emotions (e.g., amusement) in comparison with other forms of smiling (Ekman et al., 1990), their experimental manipulation may be useful in determining whether stronger peripheral feedback effects are specifically related to some prototypical facial patterns.

Duchenne Smiling and Emotional Experience

Although it is widely accepted that smiling provides salient communicative signals for regulating social exchanges, the view that smiling can be seen as a readout of inner positive emotions is somewhat controversial. Observational and psychophysiological studies have shown that activity of zygomaticus major is correlated to the perception of a wide range of pleasant stimuli (Cacciopo, Petty, Losch, & Kim, 1986; Dimberg, 1982; Ekman, Friesen, & Ancoli, 1980). Conversely, a number of reports indicated that positive emotional states (e.g., pleasure, happiness) alone are neither sufficient nor necessary to produce smiles (Fernández-Dols & Ruiz-Belda, 1997; Fridlund, 1994). In addition, smiling may occur in various social contexts wherein there may be little positive feeling (e.g., conversation, submissiveness, embarrassment) or may be also related to ongoing negative emotion during deceitful interactions (Ekman et al., 1988; Fridlund, 1991; Keltner, 1995; Kraut & Johnston, 1979; Lafrance & Hecht, 1999; Provine & Fischer, 1989; Soussignan & Schaal, 1996a). Thus, available data suggest that the correspondence between smiling and positive feelings is far from clear.

To clarify this issue, Ekman and Friesen (1982) suggested that variants of human smile could be distinguished on the basis of a number of behavioral markers (i.e., morphology, intensity, timing, location, laterality). More particularly, "felt/enjoyment" (or Duchenne) smiles have been distinguished from "false" (or non-Duchenne) smiles on the basis of the presence of orbicularis oculi activation, as marked by crow's feet wrinkles in the eye region (Ekman, 1989; Ekman & Friesen, 1982). Several studies have obtained evidence that Duchenne smiles occurred more often than other types of smiling when adult participants watched pleasant films or when they self-reported amusement during both solitary and social situations (Ekman et al, 1990; Ekman & Friesen, 1982; Frank, Ekman, & Friesen, 1993). In infants, Duchenne smiles are more often displayed at the approach of their mother rather than a stranger or during mother–infant–object play (Dickson et al., 1997; Fox & Davidson, 1988). In school-age children, they are shown more frequently during success than they are in failure in a game (Schneider & Unzner, 1989). Other studies have also revealed that compared with other forms of smiling, Duchenne smiles (a) are of greater intensity, (b) differ in dynamic markers and social signal value, (c) induce empathy, and (d) are correlated with a distinct pattern of regional electroencephalographic activation (Davidson, Ekman, Saron, Senulius, & Friesen, 1990; Ekman et al., 1990; Fox & Davidson, 1988; Frank et al., 1993; Soussignan & Schaal, 1996b; Surakka & Hietanen, 1998).

In sum, although experience of pleasure or enjoyment is not necessarily linked to the expression of smiles (e.g., Fernández-Dols & Ruiz-Belda, 1995), available data support the view that it is heuristically useful to make a distinction between Duchenne and non-Duchenne smiles, as they have distinct experiential, situational, and cerebral correlates.

Aims of the Present Study

The questions raised by Strack et al.'s (1988) study led us to design a study targeting three major objectives. The first objective was to replicate and extend their work by examining more stringently the facilitating influence of manipulated zygomatic action on self-reported emotional experience and autonomic nervous system activity. The integration of autonomic parameters is relevant as they are less susceptible to demand characteristics than are self-report data. We used a variation of Strack et al.'s pen-holding procedure with two additional groups (i.e., faces without emotional actions and faces with Duchenne's marker). In addition, potentially confounding factors such as task unpleasantness and task difficulty were controlled for. During a pencil-holding task, participants' faces were filmed while they were shown both negative and positive videoclips. This procedure was used to control for the methodological issues mentioned above (i.e., use of a valid analog of emotion, selection of faces with the requested actions, control of intensity and duration of movements). A replication of Strack et al.'s study would strengthen the hypothesis that cognitive mediation, but also potential confounding factors such as task unpleasantness, lacks of adequate facial control, and presence of additional actions do not explain the facial effects observed.

The second objective of the present study was to test whether distinct patterns of smiles (non-Duchenne smile vs. Duchenne smile) differentially influenced subjective and autonomic responding. A greater facilitating effect of Duchenne smiles on both subjective and autonomic responses was expected because correlational studies have demonstrated their strong relationship with positive emotions. More specifically, we examined two issues. First, in accordance with the monotonicity hypothesis, we predicted that the strength of smile (Duchenne vs. non-Duchenne) would positively covary with the intensity of emotional experience and physiological arousal. This hypothesis was tested because Duchenne smiles are typically associated with greater zygomatic intensity (Frank et al., 1993). Second, in comparing Duchenne smiles to non-Duchenne smiles of similar zygomatic intensity, we wanted to examine whether the morphology of smiling (due to the presence of orbicularis oculi action) would increase the subjective and physiological reactions associated with various emotional stimuli. This hypothesis was explored because it has been suggested that feedback effects should be stronger when facial configurations most closely match pure emotional expressions (Hager & Ekman, 1981; Levenson et al., 1990).

Finally, we focused on some stimulus parameters (e.g., valence, intensity) under which the facial effects would be most powerful. A number of psychophysiological studies reported that both intensity and valence of affective stimuli potentiated facial electromyographic (EMG) activity (Cacioppo, Bush, & Tassinary, 1992; Cacioppo et al., 1986; Greenwald, Cook, & Lang, 1989). For instance, EMG activity over the cheek (zygomaticus major) and the periocular (orbicularis oculi) muscle regions tended to be higher when pleasant scenes were presented. Furthermore, EMG activity over the orbicularis oculi muscle differentiated between moderately and mildly positive conditions (Cacioppo et al., 1986). Thus, we wanted to know whether feedback effects from specific patterns of smiles would be constrained by both the congruity (i.e., related to positive stimuli) and intensity value (i.e., relative to intense emotional experience) of the stimulus used. More specifically, we examined whether the potentially modulating effects of Duchenne smiling would be better predicted by stimuli that were evocative of highly positive affect (e.g., funny cartoons).

Method

Participants

Ninety-six female undergraduates participated in this study as part of a psychophysiological course requirement. Only female participants were chosen because of large difference of gender ratio in this course (women–men ratio = 10:1). They ranged in age from 21 to 28 years. Participants were randomly assigned to four conditions (i.e., control, lips pressing, non-Duchenne smiling, Duchenne smiling). The randomization design was performed so that each participant was drawn from the population before the study began, with a total of 24 participants per condition. Thus, each participant was a priori assigned to one of the four groups.

Stimulus Selection

The stimulus materials used were eight 10-s silent video records. The video excerpts were chosen from a large sample of 28 videotaped items (e.g., landscapes, animals, cartoons, mutilated body) intended to induce both moderate and strong negative or positive affect. This preliminary rating was conducted on 20 female undergraduates ranging in age from 19 to 27 years. Prior to the experiment, they were told that their subjective emotional reactions to various videoclips would be studied. After viewing each videotaped scene, the judges were asked to rate their emotional reactions on a scale ranging from −9 (*very negative*) to 9 (*very positive*) and then to report dichotomously whether they found the positive stimulus as either pleasant or funny. This qualitative description of valence was asked only in the selection procedure. It was intended to ensure that the selected cartoons were really funny. The results revealed that cartoons tended to evoke the strongest self-reported positive reactions and were judged as funny. Stimuli such as landscapes and young animals induced weak or moderate positive experience and were judged pleasant. Because our aim was to measure whether the potentially facilitating effects of smiling were better predicted by stimuli that are evocative of highly positive affect (e.g., cartoons), we selected stimuli that induced positive or negative emotional experience with different degrees of intensity. The mildly positive scenes were a lake landscape ($M = 4.00$, $SD = 2.51$) and a baby chimpanzee on a tree ($M = 4.80$, $SD = 2.87$), whereas the more strongly positive scenes consisted of cartoons taken from the *Tex Avery* ($M = 5.68$, $SD = 3.31$) and *Tom & Jerry* series ($M = 7.65$, $SD = 1.39$). A cut-off criterion of 5 was used to classify the stimuli as evocative of mildly or strongly positive emotional reactions. A two-way repeated-measures analysis of variance (ANOVA), with Intensity and Stimulus as within-subject factors, indicated that the judges reacted more positively to cartoons ($M = 6.67$, $SD = 1.41$) than to videoclips representing the landscape and the chimpanzee ($M = 4.42$, $SD = 1.58$), $F(1, 19) = 97.40$, $p < .001$. Similarly, on the negative pole, the judges reacted more negatively to some videoclips than to others. The mildly unpleasant scenes portrayed a vampire bat sucking the blood of a hen ($M = -3.30$, $SD = 2.88$) and ants moving on caterpillar larvae ($M = -4.90$, $SD = 3.02$). Finally, the two most unpleasant scenes consisted of a physician examining a child whose toes were amputated ($M = -6.95$, $SD = 2.06$) and a person scraping and stretching the skin of a dead animal ($M = -7.25$, $SD = 2.27$). A cut-off point of 5 was used to classify the stimuli as inducing mildly or strongly negative emotional reactions. A two-way ANOVA (Intensity × Stimulus) revealed that the judges responded more negatively to the videoclips showing amputated toes and a scraped animal ($M = -7.10$, $SD = 1.59$) than to those showing the bat and ants ($M = -4.10$, $SD = 2.46$), $F(1, 19) = 29.48$, $p < .0001$.

Apparatus and Psychophysiological Recording

The autonomic measures (i.e., skin conductance, heart rate, respiratory rate, bodily temperature) were continuously monitored using a 4-channel MacLab system (ADInstruments Pty Ltd.; Castle Hill, New South Wales, Australia), which was connected to a Macintosh computer. The bioelectrical signals were filtered and amplified before being fed into the analog input connector of the MacLab hardware unit and sampled at a rate of 20 points/s under the on-line control of the MacLab application program (Chart 3.5.2. software).

Heart rate was measured using Ag/AgCl electrodes and a standard Lead II electrode configuration. A low-pass filtering of 50 Hz was used with the bioamplifier to eliminate high-frequency components. A computed input command allowed a threshold control to detect R wave pulses.

Skin conductance level was recorded using a conducting gel and Ag/AgCl electrodes attached with a Velcro strap on the volar surface of the distal phalanges of the second and third fingers of the right hand. An UFI Bioderm skin conductance coupler (model 2701; Morro Bay, CA) provided a constant 0.5 V across electrodes, and the sensitivity was set at 250 mV/μmho.

Respiratory rate changes were recorded by a solid-state transducer (UFI model 1132 Pneumotrace; Morro Bay, CA) strapped around the thoracic region. The piezoelectric device of the pneumobelt responded linearly to changes in elongation generating a positive voltage as its length increased.

Bodily temperature was recorded through a type-T thermocouple sensor (time constant: 0.3 s, resolution: 0.1°C) insulated in a 1.3 mm diameter Teflon lead. The sensor was placed on the medial part of the forehead and connected—via a Bat-10 thermometer—to the computer-based data acquisition system for direct temperature readings. A 50-Hz low-pass signal filtering was selected to remove high-frequency noise.

Procedure

On arrival, participants were seated in a recliner in a 3 m × 1.5 m cubicle. Then, the following cover story based on that used by Strack et al. (1988) was given:

> This research is part of a project on physically handicapped persons who are unable to use their hands to exercise control over their environment. However, one may expect that training would make these persons able to use other parts of their body (mouth, feet) in order to do daily routine psychomotor or cognitive tasks (e.g., to use a pen/pencil to complete a questionnaire, to direct a remote control in order to run a television, to use a telephone). It is obvious that their ability to exercise control over their milieu with different parts of their body may contribute to improve the quality of their future life. What we would like to know is whether the manipulation of objects (e.g., pencil, remote control) by other parts of the body (e.g., the mouth) may affect the attentional abilities and the responsiveness of these persons because of the potentially negative side effects of this task (e.g., due to difficulty and unpleasantness). Before conducting such a study in physically impaired people it is important to collect data in non-handicapped persons, not only to perfect the procedure but also to provide information on the performances and reactions of a control group. The tasks we would like you to perform aim specifically (a) at assessing your reactions to a particular pencil-holding technique with the mouth (i.e., difficulty and pleasantness of the task), (b) at examining the effect of this technique on both your psychomotor performance (to underline some targets), and attention to videotaped scenes broadcast on a television screen. A pencil will be used because it is a usual daily object and it can also simulate a remote control (e.g., to run a television). Several techniques of pencil holding will be compared (pencil held with the teeth or with the lips) because an important aim of this research is to select the most adequate and the least cumbersome. We will compare data of four experimental groups (i.e., four techniques of pencil holding), but each participant will be only assigned to one technique. To ensure you have carefully followed experimenter's instructions, the procedure will be videotaped. We are asking you to do two tasks. The first task consists in holding a pencil with the mouth (one of the four techniques), to direct it towards some specific targets on a sheet (i.e., vowels), and to underline them quickly when the experimenter will signal you (psychomotor task). In the second task, you will also have to hold the pencil with the mouth, and to direct it towards the television facing you by focusing your attention on the video records that last 10 s (attention task). The pencil will simulate a remote control. Several variables will be measured to check whether the object holding affects both your perception, attention, and induces unpleasantness: self-report items of a questionnaire and psychophysiological parameters.

Each participant signed a consent form indicating her acceptance of the procedure and her permission for further use of video records. For each task an experimenter demonstrated the correct way to hold the pencil.[1] Then, after putting another new pencil to

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[1] Each pencil-holding condition was demonstrated twice by a certified Facial Action Coding System (FACS; Ekman

Figure 1. Illustration of the technique used to induce distinct facial configurations: (a) jaw dropping (control group), (b) lips pressing (lips pressing group), (c) lips corner pulling (non-Duchenne smile group), and (d) lips corner pulling and cheeks raising (Duchenne smile group).

participants' lips, the experimenter asked them to reproduce the action. A lightweight pencil was chosen to reduce muscular effort required to hold the object (diameter: 7 mm, length: 17 cm, weight: 10 g). The four following experimental conditions were defined (see Figure 1 for examples):

In the first condition (the control group; CG), participants were instructed to hold the pencil between the teeth. It was emphasized that they should open slightly their lips without touching the object (i.e., maintaining 3 or 4 mm between the lips and the pencil). This task involved the lowering of the mandible (producing action unit [AU] 26, or jaw dropping in the Facial Action Coding System [FACS; Ekman & Friesen, 1978] terminology)[2] produced by the relaxation of temporal and internal pterygoid muscles. In the second condition (the lips pressing group; LPG), participants were instructed to tightly hold the pencil with the lips without touching it with their teeth. This AU involved the muscular contraction of the orbicularis oris muscle that produces the pressing of lips (AU 24, or lips pressing in the FACS terminology). In the third and fourth conditions, participants were instructed to avoid any contact of the lips with the pencil by holding it with their front teeth and by reproducing the level of action produced by the experimenter during the task. Participants were told that this condition was included because objects of distinct size might be manipulated during everyday life. Thus, they thought that distinct levels of teeth conditions were required to take into account the diversity of daily situations. The third condition (the non-Duchenne smile group; n-DSG) involved both the

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& Friesen, 1978) coder (Robert Soussignan). The first time, the experimenter showed the correct way to hold the pencil during about 5 s. After the participants had performed the requested task, the experimenter showed the correct technique a second time during the same duration, and again he instructed the participants to perform the task.

[2] The FACS is a comprehensive anatomically based technique developed by Ekman and Friesen (1978) for measuring all minimally observable facial changes that muscles can produce (action units; AU). Each AU is designated by a numeric code and scored on the basis of precise transitory changes in the shape and location of the facial features such as wrinkles, bulges, or pouches of the skin. FACS intensity ratings range from A (*very slight intensity*) to E (*strongest possible intensity*).

contraction of zygomaticus major muscles at a C level (producing AU 12, or lips corner pulling in the FACS terminology) and the relaxation of temporal and internal pterygoid muscles, whereas in the fourth condition (the Duchenne smile group; DSG) the contraction of zygomaticus major muscles was performed at a D level, in conjunction with orbicularis oculi muscles[3] (producing AU 6, or cheek raising in the FACS terminology). Thus, no instructions were given to direct the participants' attention on smiling patterns or on the muscles responsible for zygomatic and orbicularis oculi actions. In addition, participants were not asked to voluntarily produce AU 6, nor were they submitted to systematic trials and training to correct the expressions. Only distinct levels of pencil avoidance with the lips were required. It was expected that both this instruction and the reproduction of the holding technique shown by the model would have increased the probability that the participants displayed Duchenne smiles.

Following the instruction phase, physiological sensors were attached, and participants were asked to remain quiet throughout the experiment. Then, they performed the two tasks. In the psychomotor task, they were shown 11 consonants and 2 vowels printed randomly on a sheet of paper. Then, after the pencil was put into their mouth (teeth or lips conditions), they were told to underline only the vowels as quickly as they could at a signal given by the experimenter. After doing so, the performance time was noted, and they were instructed to verbally report the degree of task difficulty on a 10-point scale (0 = *not at all difficult* to 9 = *very difficult*) and the degree of pleasantness of the pencil-holding technique on a scale ranging from –9 (*very unpleasant*) to 9 (*very pleasant*). In the attention task, the participants were told that they would be shown several short films and they should use the same technique of pencil holding by directing their attention on videotapes. They were told that videoclips were selected to be more or less pleasant and more or less funny. The video records were shown on a 72-cm television screen placed at a distance of 2.5 m from the participants face. The presentation of the positive and negative video records was randomized in a single order. Following a 90-s rest period, the pencil was put into their mouth by the experimenter, and the videotaped sequence was projected. During the projection, the experimenter stayed behind the participants and did not look at the videoclips. At the end of each sequence the pencil was taken and put on a paper tissue. After viewing each video record, the participants were asked, "How did you react to the videoclip?" The response scale to the scene ranged from –9 (*very negatively*) to 9 (*very positively*). They were also instructed to report (a) the degree of pleasantness of the pencil-holding procedure on a scale ranging from –9 (*very unpleasant*) to 9 (*very pleasant*) and (b) the degree of difficulty of the pencil-holding technique on a 10-point scale ranging from 0 (*no difficulty*) to 9 (*very difficult*). Participants' attention was then evaluated by asking them a question about the scene content.

Finally, the participants were instructed to hold the pencil with their teeth or lips, corresponding to the respective condition, for 10 s while the emotional stimuli were not projected. Although they were told that this recording aimed to investigate the specific effect of pencil-holding techniques on physiological parameters, this test was included to examine whether changes of autonomic response patterns (heart rate, respiration, skin conductance, temperature) were not directly the consequence of differences in muscular effort-related changes between the pencil-holding techniques regardless of the projection of video scenes.

Debriefing About the Purposes of the Experiment

At the end of the experiment, the participants were instructed to identify and describe the purposes of the

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[3] In a moderate smiling (i.e., B or C level) the minimum criteria for scoring AU 12 are the following (Ekman & Friesen, 1978): (a) Skin in the areas of the lower-middle portion of the nasolabial furrow or the furrow itself has been raised up and is slightly lateral, (b) slight evidence that infraorbital triangle has been raised, and (c) slight evidence that lip corners are elongated and angled up. A strong smiling (i.e., a D or E level recruiting AU 6) produced additional changes: (a) presence of crow's-feet wrinkles, (b) marked narrowing of the eyes opening, and (c) slight infraorbital triangle raise. In a strong smiling without AU 6, the appearance changes due to AU 12 are more pronounced (i.e., the infraorbital triangle upward push is more evident, the infraorbital furrow deepening is more evident). It can be noted that a Duchenne smile with a B or C level is uncommon, and when smiling reaches a D or E level, Duchenne smiling is often produced (Ekman & Friesen, 1978). So, it was expected that reproducing a pencil-holding task with intense lip movement would induce cheeks raising with furrows in the eye region (because of the contraction of orbicularis oculi muscles). However, it can be noted that our instructions did not always induce Duchenne smiles despite the fact that participants indeed produced a D-level zygomatic action in the teeth condition. This explains why about 30% of participants of this group were later excluded from the analysis.

study on a paper sheet. They were also asked to report purposes that were not given in the instruction procedure. None of participants suspected the true nature of experimental hypotheses. Most of them reported that the goals were to devise an appropriate object-holding procedure and to test its interference with daily tasks in order to make the life easier for motor handicapped persons. Thus, it can be concluded that the cover story was really effective.

Facial Control and Data Reduction

The recording of each participant's face was later inspected by a certified coder who had previously taken a FACS final proficiency test. This coding system was used during the previous 10-s baseline period and the 10-s pencil-holding period to verify that the facial displays (a) did not contain extraneous muscle movements (e.g., brow lowering, upper-lip raising) and (b) were consistent with the instructions regarding the required actions.

Among the participants, 28 failed to exhibit the strictly required patterns of facial actions. In this subsample, a number of participants expressed additional AUs, besides the requested facial patterns, while they were presented with the stimulus ($n = 21$). They were thus excluded from the analysis.[4] A second subsample ($n = 7$), drawn from the DSG, failed to display AU 6 (cheek raising) despite the fact that they produced the same zygomatic intensity (i.e., D-level intensity). Consequently, two comparisons were made. First, the analysis testing the monotonicity hypothesis compared data of the following groups: CG ($n = 15$), LPG ($n = 18$), C-level n-DSG ($n = 18$), and DSG ($n = 17$). Second, we explored the role of the morphology of smiling (due to orbicularis oculi activity) by comparing the DSG to the subsample of n-DSG showing the same zygomatic intensity (i.e., D-level n-DSG).

Second-by-second values for each autonomic measure were averaged for each of the two epochs: the 10-s prestimulus period and the 10-s stimulus period. Dependent variables were computed off-line from these measures by subtracting for each trial the mean of psychophysiological data (i.e., heart rate, respiratory rate, skin conductance, bodily temperature) during the prestimulus level (i.e., 10 s prior to each stimulus presentation) from the mean of the psychophysiological data during the 10 s of stimulus presentation.

Statistical Analyses

Emotional ratings and autonomic measures were analyzed using 4 × 2 × 2 × 2 (Facial Configuration × Valence × Intensity × Stimulus) repeated-measures analyses of covariance (ANCOVAs), with Facial Configuration as a between-subjects factor and the other variables as within-subjects factors. Mean ratings of task difficulty and task pleasantness were entered as covariates. Fisher's least significant difference test (LSD; Winer, 1971) was used for making post hoc multiple comparisons between means. The strength of experimental effects and the effect sizes were also reported using respectively eta-squared (η^2), and $\Phi' = \sqrt{\eta^2 / 1\text{-}\eta^2}$ as measures (Cohen, 1988; Howel, 1992). Cohen (1988) has defined a small effect as $\Phi' = 0.10$, a medium effect as $\Phi' = 0.25$, and a large effect as $\Phi' = 0.40$.

Results

Facial Configurations Comparisons

Self-reported emotional reaction. The ANCOVA yielded no significant effects for the ratings of task pleasantness, $F(1, 62) = 0.47$, *ns,* and task difficulty, $F(1, 62) = 0.21$, *ns,* as covariates. As expected, there was a significant main effect of Valence, $F(1, 62) = 209.11$, $p < .0001$ ($\eta^2 = 0.771$, effect size = 1.83), and significant Valence × Intensity, $F(1, 62) = 45.54$, $p < .0001$ ($\eta^2 = 0.423$, effect size = 0.86), and Valence × Stimulus interactions, $F(1, 62) = 13.98$, $p < .0001$ ($\eta^2 = 0.184$, effect size = 0.47), on the self-reported emotional response to the videoclips. Post hoc comparisons revealed that participants responded with more strongly positive reactions to cartoons ($M = 6.49$, $SE = 0.22$) than they did to pleasant videoclips ($M = 5.23$, $SE = 0.26$, for landscape and chimpanzee stimuli), $p = .001$. The strongly unpleasant scenes induced more negative emotional reactions ($M = -5.72$, $SE = 0.26$, for videoclips of mutilation and stretched animal) than did the mildly unpleasant scenes ($M = -2.60$, $SE = 0.33$, for videoclips of the bat and ants), $p < .0001$.

In sum, although participants of the main experiment tended to report less negative emotional experience to unpleasant scenes than to those of the stimulus selection procedure, a clear differentiation was found

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[4] The following AUs were displayed during the presentation of the video records: AU 4 (brow lowering), AU 1 + 4 / 1 + 2 + 4 (brow raising and lowering), AU 10 (upper-lip raising), AU 17 (chin raising), and AU 20 (lip stretching). These facial actions were shown to be signs of various negative affects (e.g., Ekman et al., 1980). Therefore, the participants displaying negative AUs were excluded.

between videoclips that were mildly and strongly evocative of positive or negative affect.

More interesting, the main effect for Facial Configuration was significant, $F(3, 62) = 4.33, p = .008$ ($\eta^2 = 0.173$, effect size = 0.46). Post hoc pairwise comparisons showed that the DSG, on average, reacted more positively to the videoclips compared with other groups of participants: DSG vs. CG: $p < .01$; DSG vs. LPG: $p < .01$; DSG vs. n-DSG: $p < .05$ (see Figure 2).

The Facial Configuration × Valence interaction was not significant, $F(3, 62) = 1.32, p = .27$. However, the Facial Configuration × Valence × Intensity interaction approached significance, $F(3, 62) = 2.30, p = .08$ ($\eta^2 = 0.1$, effect size = 0.33). Follow-up univariate ANCOVAs revealed main effects of Facial Configuration for positive videoclips (all *p*s < .05), whereas no significant differences emerged between the four facial configuration groups when unpleasant scenes were presented ($p > .05$).

Adjusted means and statistics are summarized in Table 1. As can be seen, only the DSG reported higher positive emotional experience during mildly and strongly intense conditions. More specifically, LSD tests revealed that the DSG reported more positive emotional ratings than did the CG (except for the landscape stimulus) and the LPG. The DSG reacted also more positively than did the n-DSG to the pleasant stimulus (landscape and chimpanzee, $p < .05$), and Cartoon 1 ($p < .05$), whereas the difference of emotional scores approached significance for the other positive stimulus (Cartoon 2, $p = 0.1$).

Inspection of effect sizes for the reported significant effects (Valence, Valence × Intensity, Valence × Stimulus, Facial Configuration) revealed that they are similar or higher than 0.4. Thus, it can be suggested that the magnitude of experimental effects is large (Cohen, 1988).

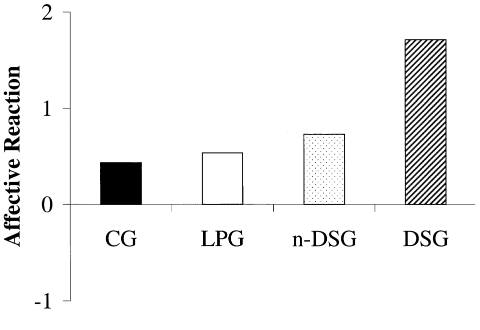

Figure 2. Self-reports of emotional reaction as a function of the type of facial configuration while participants were shown videoclips. CG = control group; LPG = lips pressing group; n-DSG = non-Duchenne smile group; DSG = Duchenne smile group.

Skin conductance. Data from two participants of the DSG were excluded because of recording artifacts. The ANCOVA performed on the skin conductance changes yielded no significant effects for the ratings of task difficulty and task pleasantness as covariates, all *p*s > .50. The Facial Configuration effect approached significance, $F(3, 60) = 2.65, p = .057$ ($\eta^2 = 0.117$, effect size = 0.36). Post hoc LSD tests indicated that the magnitude of skin conductance changes was higher for DSG as compared with other groups of participants (CG: $p = .008$; LPG: $p = .06$; n-DSG: $p = .03$). No other main effects were significant. However, the Facial Configuration × Stimulus interaction was significant, $F(3, 60) = 3.72, p < .05$ ($\eta^2 = 0.157$, effect size = 0.43), as was the Facial Configuration × Valence × Stimulus interaction, $F(3, 60) = 3.83, p < .05$ ($\eta^2 = 0.161$, effect size = 0.44). One-way ANCOVAs followed by Fisher's LSD tests revealed that these interactions reflect the fact that the DSG showed greater increases in skin conductance while exposed to one of the positive videoclips (i.e., Cartoon 1), $F(3, 60) = 4.61, p < .01$ ($\eta^2 = 0.187$, effect size = 0.48), as compared with the participants of other groups, all *p*s < .05 (see Table 2).

Heart rate. The data from one participant of the LPG were unavailable because of equipment problems. The repeated-measures ANCOVA on heart rate changes did not show any significant effect for the ratings of task pleasantness and task difficulty as covariates, all *p*s > 0.1. The analysis revealed no heart-rate differences as a function of the type of Facial Configuration, $F(3, 61) = 1.76, p = .165$. There were also no significant main effects involving Valence, Intensity, and Stimulus (all *p*s > .05). However, significant Facial Configuration × Valence × Intensity interaction, $F(3, 61) = 2.85, p < .05$ ($\eta^2 = 0.123$, effect size = 0.37), as well as Facial Configuration × Valence × Stimulus interaction, $F(3, 61) = 2.76, p = .05$ ($\eta^2 = 0.119$, effect size = 0.37) were detected. One-way ANCOVAs followed by Fisher's LSD procedure were run to elucidate the meanings of these triple interactions. As illustrated in Table 3, compared with other groups, the DSG showed a higher heart rate change while viewing one of the strongly positive videoclips (i.e., Cartoon 1), $F(3, 61) = 2.97, p < .05$, $\eta^2 = 0.128$, effect size = 0.38, (DSG vs. CG: $p < .05$; DSG vs. LPG: $p < .01$; DSG vs. n-DSG: $p = .06$). Inspection of Table 3 indicates also that both CG and LPG evinced decreases for almost all the videoclips, whereas the DSG showed increased heart rate

Table 1

Adjusted Mean, Standard Error, and Effect Size for Self-Report of Emotional Experience During the Four Facial Configurations as a Function of Affective Valence and Intensity Dimension of Videoclips

	Positive								Negative							
	Mildly				Strongly				Mildly				Strongly			
	Landscape		Chimpanzee		Cartoon 1		Cartoon 2		Bat		Ants		Stretched animal		Mutilation	
Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
CG ($n = 15$)	4.66	0.76	5.03[a]	0.55	5.32[a]	0.55	6.00[a]	0.52	−1.78	0.98	−4.62	1.03	−5.35	0.68	−5.45	0.77
LPG ($n = 18$)	3.46[a]	0.67	5.11[a]	0.49	5.94[a]	0.49	5.98[a]	0.46	−1.31	0.87	−3.47	0.91	−5.34	0.60	−6.27	0.68
n-DSG ($n = 18$)	4.16[a]	0.67	5.93[a]	0.39	6.29[a]	0.48	6.87	0.46	−1.40	0.86	−3.30	0.91	−6.60	0.60	−6.26	0.68
DSG ($n = 17$)	6.18	0.69	7.34	0.50	7.65	0.50	7.86	0.47	−1.49	0.89	−3.40	0.94	−4.80	0.62	−5.68	0.70
F	2.89*		4.60**		3.66*		3.42*		0.45		0.36		1.57		0.33	
η^2	0.123		0.182		0.151		0.142		0.002		0.017		0.071		0.016	
effect size	0.37		0.47		0.42		0.41		0.04		0.13		0.28		0.13	

Note. Asterisks indicate that univariate analyses of covariance revealed significant differences between the four conditions of facial configuration ($df = 3, 62$).
CG = control group; LPG = lips pressing group; n-DSG = non-Duchenne smile group; DSG = Duchenne smile group.

[a] Mean differences between the DSG and other groups are significant at $p < .05$.

* $p < .05$. ** $p < .01$.

Table 2

Adjusted Mean Change From Previdеoclip Period and Standard Error for Skin Conductance Level During the Four Facial Configurations as a Function of Affective Valence and Intensity Dimension of Videoclips

Condition	Positive								Negative							
	Mildly				Strongly				Mildly				Strongly			
	Landscape		Chimpanzee		Cartoon 1		Cartoon 2		Bat		Ants		Stretched animal		Mutilation	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
CG (*n* = 15)	0.53	0.25	0.30	0.26	0.15	0.24	0.40	0.21	0.27	0.25	0.20	0.20	0.21	0.19	0.21	0.10
LPG (*n* = 18)	0.90	0.23	0.75	0.23	0.11	0.22	0.48	0.19	0.52	0.23	0.36	0.19	0.42	0.17	0.19	0.21
n-DSG (*n* = 18)	0.74	0.23	0.79	0.23	0.14	0.22	0.23	0.19	0.39	0.22	0.38	0.19	0.27	0.17	0.30	0.21
DSG (*n* = 15)	1.43	0.26	0.89	0.26	1.19[a]	0.24	0.03	0.21	0.77	0.25	0.49	0.20	0.75	0.19	0.88	0.23

Note. CG = control group; LPG = lips pressing group; n-DSG = non-Duchenne smile group; DSG = Duchenne smile group.

[a] Mean differences between the DSG and other groups are significant at $p < .05$.

Table 3

Adjusted Mean Change From Previdеoclip Period and Standard Error for Heart Rate During the Four Facial Configurations as a Function of Affective Valence and Intensity Dimension of Videoclips

	Positive								Negative							
	Mildly				Strongly				Mildly				Strongly			
	Landscape		Chimpanzee		Cartoon 1		Cartoon 2		Bat		Ants		Stretched animal		Mutilation	
Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
CG ($n = 15$)	−0.25	1.71	−0.22	1.21	−1.06	1.11	−0.96	0.98	−2.69	1.44	−2.53	1.25	−0.19	1.40	0.09	1.13
LPG ($n = 17$)	−2.99	1.56	−0.34	1.11	−1.37	1.02	−0.98	0.90	−0.85	1.31	−0.002	1.14	−1.69	1.28	−3.44[a]	1.03
n-DSG ($n = 18$)	0.42	1.50	0.06	1.06	−0.20	0.98	1.33	0.86	1.44	1.27	−0.55	1.10	−0.05	1.23	−0.24	0.99
DSG ($n = 17$)	−1.54	1.55	2.56	1.10	2.49[a]	1.00	1.26	0.89	0.19	1.30	0.71	1.13	−0.66	1.27	0.23	1.03

Note. CG = control group; LPG = lips pressing group; n-DSG = non-Duchenne smile group; DSG = Duchenne smile group.

[a] Mean differences between the groups are significant at $p < .05$.

for three positive videoclips. In addition, compared with other groups, the LPG showed a higher decrease of heart rate while viewing one of the most unpleasant videoclips, $F(3, 61) = 2.79$, $p < .05$, ($\eta^2 = 0.121$, effect size = 0.37).

Respiratory rate. Using respiratory rate as the dependent variable, the 4 (Facial Configuration) × 2 (Valence) × 2 (Intensity) × 2 (Stimulus) repeated-measures ANCOVA yielded no significant effects for any of the main independent variables or for the interaction between these variables ($p > .05$).

Bodily temperature. The four-factor ANCOVA (Facial Configuration × Valence × Intensity × Stimulus) also yielded no significant effects for the main independent variables or for the interaction between these variables ($p > .05$).

Form of Smiling

When smiles with the Duchenne marker are spontaneously displayed during solitary and social interaction situations, they are characterized by greater zygomatic intensity than are smiles without the Duchenne marker (Frank et al., 1993). Thus, Duchenne smiles may be differentiated from non-Duchenne smiles in both morphology (presence of orbicularis oculi action) and intensity. In our study, the induction of Duchenne smiles was based on a procedure that generated zygomatic actions of greater intensity than those of non-Duchenne smiles. Thus, the above findings may result not solely from the additional recruitment of the orbicularis oculi action but also from the greater intensity of zygomatic major action. Although, our main purpose was not to disentangle the relative contribution of these two behavioral markers in the facial modulation of experiential and physiological measures, we compared the findings of the DSG with data collected in a subsample of participants ($n = 7$), who initially belonged to the DSG but who were excluded because their facial pattern did not recruit the Duchenne marker, despite the fact that they showed evidence of a zygomatic major action at D level[5] (i.e., D-level n-DSG). The C-level n-DSG was also included into the analysis as a control group.

A four-way ANCOVA (Form of Smiling × Valence × Intensity × Stimulus), with Form of Smiling (DSG, D-level n-DSG, C-level n-DSG) as the between-subjects factor and the other variables as within-subjects factors, was carried out on subjective emotional reactions to videoclips. The ratings of task pleasantness and task difficulty were entered as covariates. The analysis yielded no significant effect for task pleasantness and task difficulty as covariates, all $ps > .25$. As we expected, significant effects were detected for Valence, $F(1, 37) = 128.09$, $p < .0001$ ($\eta^2 = 0.776$, effect size = 1.86); Intensity, $F(1, 37) = 4.23$, $p < .05$ ($\eta^2 = 0.103$, effect size = 0.34); Valence × Intensity interaction, $F(1, 37) = 46.10$, $p < .001$ ($\eta^2 = 0.55$, effect size = 1.10); and Valence × Stimulus interaction, $F(1, 37) = 4.92$, $p < .05$ ($\eta^2 = 0.117$, effect size = 0.36). There was also a significant main effect for Form of Smiling, $F(2, 37) = 5.02$, $p < .05$ ($\eta^2 = 0.213$, effect size = 0.52). Follow-up univariate ANCOVAs followed by Fisher's LSD tests revealed that the DSG reported greater positive reaction than did the D-level n-DSG while viewing pleasant and funny videoclips (landscape: $p < .05$, chimpanzee: $p < .01$, Cartoon 1: $p < .05$), whereas no significant difference was detected between the two non-Duchenne conditions (see Table 4). Inspection of effect sizes for the significant findings indicated that they are higher than 0.4. Thus, it can be suggested that the effects are large.

Four-way ANCOVAs (Form of Smiling × Valence × Intensity × Stimulus) were also conducted on each autonomic measure, with Form of Smiling as the between-subjects factor and the other variables as within-subjects factors. The pleasantness ratings and the difficulty ratings of the task were entered as covariates.

For skin conductance, no significant main effects were detected. However, there were significant interactions between Form of Smiling and Stimulus, $F(2, 35) = 6.53$, $p < .01$ ($\eta^2 = 0.272$, effect size = 0.61), as well as between Form of Smiling, Valence, and Stimulus, $F(2, 35) = 7.05$, $p < .01$ ($\eta^2 = 0.287$, effect size = 0.63). Follow-up one-way ANCOVAs followed by LSD tests indicated that the DSG exhibited higher increases in skin conductance than did the D-level n-DSG only for the landscape videoclip ($M = 1.43$ vs. 0.29), $F(2, 35) = 4.08$, $p < .05$ ($\eta^2 = 0.215$, effect size = 0.52).

For heart rate, there also was a Form of Smiling × Valence × Stimulus interaction, $F(2, 37) = 3.73$, $p < .05$ ($\eta^2 = 0.168$, effect size = 0.45). The other ef-

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[5] Given that the criterion of differentiation between the Duchenne and the non-Duchenne smile groups was originally based on the degree of avoidance of the pencil, intensity and presence of orbicularis oculi action were obviously confounded. However, as it can be remembered, this choice was dictated by the necessity to recruit the orbicularis oculi action without asking participants to contract the muscle responsible of this action to rule out situational demands.

Table 4

Adjusted Mean, Standard Error, and Effect Size for Self-Report of Emotional Experience During Videoclips as a Function of the Form of Smiling

	Positive								Negative							
	Mildly				Strongly				Mildly				Strongly			
	Landscape		Chimpanzee		Cartoon 1		Cartoon 2		Bat		Ants		Stretched animal		Mutilation	
Condition	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
C-level n-DSG ($n = 18$)	4.24[a]	0.62	5.95[a]	0.46	6.27[a]	0.40	6.88	0.37	−1.42	0.94	−3.35	0.89	−6.67	0.60	−6.23	0.67
D-level n-DSG ($n = 7$)	3.61[a]	1.00	4.94[a]	0.74	6.28[a]	0.64	6.79	0.60	−1.36	1.51	−2.28	1.43	−4.71	0.97	−4.93	1.08
DSG ($n = 17$)	6.26	0.64	7.37	0.47	7.65	0.41	7.86	0.39	−1.52	0.96	−3.45	0.92	−4.88	0.62	−5.67	0.69
F	3.66*		4.72*		3.39*		2.04		0.005		0.26		2.66		0.55	
η^2	0.165		0.203		0.155		0.099		0.0		0.01		0.126		0.029	
Effect size	0.44		0.50		0.43		0.33		0.0		0.10		0.38		0.17	

Note. C-level n-DSG = C-level non-Duchenne smile group; D-level n-DSG = D-level non-Duchenne smile group; DSG = Duchenne smile group. Asterisks indicate that univariate analyses of covariance revealed significant differences between the four conditions of facial configuration ($df = 2, 37$).

[a] Mean differences between the DSG and other groups are significant at $p < .05$.

* $p < .05$.

fects were not significant. Post hoc comparisons indicated that this interaction reflects the fact that the DSG globally reacted more to some positive videoclips (i.e., chimpanzee and Cartoon 1: *M* = 2.57, *SE* = 1.08) than to others (landscape and Cartoon 2: *M* = –0.16, *SE* = 1.06), as compared with the n-DSG groups, $p < .05$.

Finally, for respiratory rate and bodily temperature, there were no other significant main or interaction effects.

Pleasantness and Difficulty Ratings of the Pencil-Holding Tasks

Although the ANCOVAs revealed that the findings were not produced by differences in the degree of pleasantness and difficulty of the four experimental conditions, additional analyses were performed to verify whether participants differentially reacted to the distinct pencil-holding tasks. A 5 (Facial Configuration) × 2 (Valence) × 2 (Intensity) × 2 (Stimulus) repeated-measures ANOVA was conducted on the pleasantness scores. There were no significant main effects associated with any of these variables. Comparison of means of the five groups of participants performing the distinct pencil-holding techniques indicated that they self-reported similar ratings of slight unpleasantness, $F(4, 70) = .10$, $p = .98$ (CG: *M* = –1.36, *SE* = 0.72; LPG: *M* = –0.95, *SE* = 0.65; C-level n-DSG: *M* = –1.33, *SE* = 0.65; D-level n-DSG: *M* = –1.68, *SE* = 1.05; DSG: *M* = –1.23, *SE* = 0.67). Significant differences were only found for two- and three-way interactions between Valence, Intensity, and Stimulus. For the Valence × Intensity interaction: $F(1, 70) = 7.00$, $p < .05$, $\eta^2 = 0.092$, effect size = 0.32; Intensity × Stimulus interaction: $F(1, 70) = 6.39$, $p < .05$, $\eta^2 = 0.084$, effect size = 0.30; Valence × Intensity × Stimulus interaction: $F(1, 70) = 4.08$, $p < .05$, $\eta^2 = 0.064$, effect size = 0.26. These significant interactions were especially attributable to the fact that the pencil-holding techniques induced lower unpleasant scores during the presentation of cartoons (Cartoon 1: *M* = –0.68, *SE* = 0.36; Cartoon 2: *M* = –1,04, *SE* = 0.40) than they did during the presentation of highly negative scenes (stretched animal: *M* = –1.55, *SE* = 0.39, mutilation: *M* = –1.71, *SE* = 0.41, matched *t* tests, all *p*s < .05).

A second possible confounding variable that may explain part of our findings concerns the different degrees of difficulty for the four pencil-holding techniques. Examining the 5 (Facial Configuration) × 2 (Valence) × 2 (Intensity) × 2 (Stimulus) ANOVA on difficulty ratings, we detected no main effects for any of the four independent variables. Although the CG rated the pencil-holding task as less difficult compared with other facial configuration groups, the direction of the finding was contrary to the hypothesis and the difference failed to reach significance (CG: *M* = 1.83, *SE* = 0.49; LPG: *M* = 3.29, *SE* = 0.45; C-level n-DSG: *M* = 3.14, *SE* = 0.45; D-level n-DSG: *M* = 3.45, *SE* = 0.72; DSG: *M* = 3.12, *SE* = 0.46), $F(4, 70) = 1.64$, $p = .174$. The interactions between the different independent variables were also not significant.

Pearson product–moment correlation coefficients were also computed for each stimulus condition across all participants. The analysis revealed that ratings of task difficulty were negatively correlated with ratings of task pleasantness for five of the stimulus conditions, $r\,(73)$ ranged from –0.30 to –0.41, $p < .05$. Finally, no significant correlations were apparent between emotional ratings and difficulty ratings, on the one hand, and emotional ratings and unpleasantness ratings, on the other hand ($p > .05$).

Relationship Between Self-Reported Emotion and Physiological Measures

Correlations among subjective emotional reactions and physiological measures were computed for each stimulus condition across all participants. No clearly interpretable patterns emerged given the analyses revealed only a small number of significant correlations between subjective reports of affective experience and autonomic measures (i.e., Cartoon 1: $r(73) = 0.28$, $p < .05$, for skin conductance; Cartoon 2: $r(74) = 0.28$, $p < .05$, for heart rate).

Autonomic Activity During the Pencil-Holding Procedure

To investigate whether the muscular effort produced during the pencil-holding techniques influences autonomic nervous system activity, means of physiological measures 10 s before the task were subtracted from the average physiological measures collected during the 10 s period of the pencil-holding task. Data were analyzed using one-way ANOVAs on each physiological measure with Facial Configuration (CG, LPG, C-level n-DSG, D-level n-DSG, DSG) as the between-subjects factor. Statistical analyses yielded no significant differences between the five groups for the four autonomic measures: skin conductance: $F(4, 68) = 1.30$, $p = 0.28$; heart rate: $F(4, 69) = 1.67$, $p = 0.168$; respiratory rate: $F(4, 70) = 1.62$, $p = 0.179$; bodily temperature: $F(4, 70) = 0.554$, $p = 0.704$. Mean values of autonomic parameters for the five facial configurations are shown in Table 5. As can be seen, the pattern of activity varied as a function of the physiological measure: Heart rate and bodily temperature tended to decrease, whereas skin conductance and respiratory rate tended to increase during the production of the pencil-holding procedure. These findings suggest that muscular effort-related changes alone do not explain the differential pattern of autonomic responsiveness shown in the participants who displayed the Duchenne smile during the presentation of the emotional video sequences.

Discussion

This research addressed four issues derived from the facial feedback hypothesis with a methodology based on Strack et al.'s (1988) procedure (i.e., oral pencil-holding technique). The first aim was to replicate and extend their work by examining more stringently the facilitating influence of zygomatic action on self-reported emotional experience and autonomic nervous system activity. Because of a variety of limitations in their study, the present experiment included a number of methodological issues (e.g., selection of faces with the requested actions, use of a control face without emotional actions, control of intensity and duration of movement, partialling out of task unpleasantness). Our findings confirm the heuristic value of Strack et al.'s procedure in supporting the view that the unconscious facilitation of one form of human smile reliably affects the rating of emotional experience. Specifically, production of Duchenne smiles, which involves the joint actions of the zygomatic major and orbicularis oculi, increased self-report of positive experience in participants exposed to videoclips of pleasant stimuli and funny cartoons. However, contrarily to Strack et al.'s research, the present study failed to demonstrate that the contraction of zygomaticus muscles alone was sufficient to induce reliable subjective or autonomic changes. There are two possible explanations for these conflicting results. On the one hand, methodological shortcomings due to possible variations across and within their experimental conditions (e.g., difference of unpleasantness between their two pen-holding tasks, lack of an adequate facial control, presence of additional facial actions, intensity change of zygomatic action) may have contaminated part of their findings. For instance, one may wonder whether funny cartoons used in their study did not change the intensity and the form of smiling in a number of participants (e.g., recruitment of orbicularis oculi action), thus explaining the observed effects. On the other hand, procedural differences among the studies also may be proposed as an alternative explanation for our failure to find a facilitating effect of non-Duchenne smiles on positive emotional experience. Differences in duration of feedback effects (i.e., duration of lips contraction), self-report scales (self-reported positive reactions vs. funniness ratings), and stimulus material (i.e., videoclips of pleasant scenes and funny cartoons vs. magazines of funny cartoons) may have contributed to the discrepancy. Because our rating scale confounded positive responses to both pleasant and humorous stimuli, the hypothesis that non-Duchenne smiles could have a feedback effect only when people rated funniness of cartoons cannot be completely ruled out. In addition, it is possible that different participants who were asked to report their affective reaction may have construed the meaning of *reacting* in different ways (e.g., an affective reaction in terms of feeling vs. a cognitive–moral reaction toward what is shown in the clip). It is interesting that a feedback effect of non-Duchenne smiles was reported in Strack et al.'s research (Study 2) when participants were given the opportunity to differentiate between a cognitive component (i.e., perceived funniness content of cartoons)

Table 5
Mean Change in Autonomic Measures and Standard Error of the Mean as a Function of the Pencil-Holding Tasks

Condition	SC		HR		RR		BT	
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
CG (*n* = 15)	0.14	0.13	−3.90	1.10	0.11	1.43	−0.010	0.02
LPG (*n* = 18)	0.06	0.12	−4.13	1.03	3.01	1.30	−0.050	0.02
C-level n-DSG (*n* = 18)	0.28	0.12	−1.64	1.00	−1.11	1.30	−0.020	0.02
D-level n-DSG (*n* = 7)	0.37	0.18	−0.14	1.62	2.34	2.13	−0.001	0.02
DSG (*n* = 17)	0.39	0.13	−3.10	1.03	2.42	1.34	−0.040	0.02

Note. SC = skin conductance; HR = heart rate; RR = respiratory rate; BT = bodily temperature; CG = control group; LPG = lips pressing group; C-level n-DSG = C-level non-Duchenne smile group; D-level n-DSG = D-level non-Duchenne smile group; DSG = Duchenne smile group.

and an affective component (i.e., subjective feeling of amusement) of the humor response (Gavanski, 1986; Leventhal & Mace, 1970). The smiling behavior had an effect on humor reactions only when participants were asked to report their feeling of amusement.

Further research is needed to substantiate whether this lack of replication of Strack et al.'s (1988) findings is strictly dependent on methodological limitations rather than on procedural differences between the studies. In particular, it will be important to examine whether non-Duchenne smiles alone have a differential feedback effect on pleasantness and amusement ratings while controlling a number of potential methodological artifacts.

The second issue addressed by the present study was whether the strength of smiling covaries with emotional experience and physiological arousal (i.e., monotonicity hypothesis). This hypothesis predicts that the relationship between intensity of facial expression and the emotional experience should be positive (Tourangeau & Ellsworth, 1979). Our results lend largely support to this hypothesis in showing that the Duchenne smile group reacted more positively while viewing pleasant (landscape and chimpanzee stimuli) and funny (Cartoons 1 and 2) videoclips compared with the control group (except for the landscape stimulus) and the lips-pressing group. They also reported more positive emotional experience than did participants who displayed non-Duchenne smiles for three videoclips (i.e., pleasant stimuli and Cartoon 1).

Although the experimental evidence seems less convincing for physiological arousal, enhanced autonomic responding (i.e., skin conductance and heart rate) were nevertheless detected but only in participants displaying Duchenne smiles and viewing one of the positive videoclips (significance for Cartoon 1, greater increase for three videoclips). An increase in autonomic arousal has been often demonstrated in participants whose expressive behavior was facilitated (Colby et al., 1977; Hess et al., 1992; Lanzetta et al., 1976; Levenson et al., 1990; Putnam, Winton, & Krauss, 1982; Zuckerman et al., 1981). For instance, when people were instructed to produce facial configurations of happiness, skin conductance increases and heart rate changes were observed (Levenson et al., 1990). It is unclear, however, why autonomic differences were not detected in our study for the other positive videoclips when Duchenne smiles were compared with the other facial configurations. A possible explanation is that participants induced not to display a smile (control group and lips-pressing group) while watching positive videoclips were likely in a condition of suppression of expressive behavior. Gross and Levenson (1997) have shown that suppression of facial expression while participants watched amusing films elicited a mixed physiological state characterized by decreased heart rate (due to a low somatic activity), along with increased sympathetic activation. Our findings of autonomic responding in no-smiling groups are just like those described by these authors (i.e., increase of skin conductance, decrease of heart rate). Thus, although the Duchenne smile group showed autonomic activation for the positive videoclips, there is also evidence of a slight sympathetic activation (i.e., increase of skin conductance) in participants induced to display no expressive behavior while they experienced positive emotion. Whether this explanation is well-grounded requires additional research. In the future, it would be important to include neutral videoclips to test the effect of suppression of smiling behavior on autonomic patterns.

Taken as a whole our findings yield support for the monotonicity hypothesis. This assumption would be consistent with previous research, which has usually assessed the monotonicity hypothesis by comparing faces with and without emotional actions (e.g., Hess et al., 1992). A more stringent way to test the monotonicity hypothesis (i.e., a stringent version of this hypothesis) would be to verify whether the degree of contraction of specific muscular actions (e.g., increase in the intensity of zygomatic action) contribute to increase subjective experience of emotion and physiological arousal. In our study, the lack of difference for the self-report and autonomic data between participants displaying distinct intensities of zygomatic action (i.e., C-level vs. D-level n-DSG) does not support a stringent version of the monotonicity hypothesis. However, the number of participants exhibiting intense zygomatic action was small, so the findings must be cautiously interpreted. The question of whether the differential contraction of zygomaticus major muscles alone may enhance emotional states should be considered more systematically in future research.

Bearing in mind this methodological issue, the third question we addressed in this study was whether the morphology of smiling facilitates the subjective and physiological components of emotion. The comparison between the Duchenne smile group and the non-Duchenne smile group displaying the same intensity of zygomatic action (D-level n-DSG) suggested that the presence of the Duchenne marker alone (i.e., orbicularis oculi action) increased the intensity of positive emotional experience in participants who were viewing pleasant and funny videoclips. Although less clear-cut findings were obtained for autonomic measures, Duchenne smiling increased skin conductance (for landscape videoclip) and heart rate (for chimpanzee videoclip and Cartoon 1) as compared with the high-level non-Duchenne smiling (D-level n-DSG). Thus, one may assume that the additional activation of orbicularis oculi muscles, which are responsible for the presence of crow's feet wrinkles at the outer edges of eyes, provides an input for mediating the observed emotional changes. It is interesting that the Duchenne smile has been often considered as a felt or enjoyment smile, whereas the non-Duchenne smile has been described as an unfelt smile (Ekman & Friesen, 1982; Frank et al., 1993). Pleasant stimuli (e.g., films, odors), affiliative interactions, and success in achievement games were shown to elicit more often smiles with the Duchenne marker than other types of smiles (Ekman et al., 1990; Fox & Davidson, 1988; Schneider & Unzner, 1989; Soussignan & Schaal, 1996b). Furthermore, EMG activity over the orbicularis oculi muscle regions differentiated not only the pleasantness of stimuli (Cacioppo et al., 1986, 1992) but also participants seeing a Duchenne smile versus those seeing a non-Duchenne smile (Surakka & Hietanen, 1998). The data of the present study confirm the validity of the morphological and functional differentiation between Duchenne and non-Duchenne smiles. They support the notion that facial action patterns that closely match specific facial prototypes have a greater influence on emotional experience (Levenson et al., 1990). These findings may explain why some psychophysiological studies did not report any relationship between zygomatic activity and self-report of pleasantness (e.g., Cacioppo et al., 1992; Fridlund, 1991). They are also compatible with a recent study showing no change in self-report of positive emotion in patients with facial neuromuscular disorders whose smiling was impaired (VanSwearingen, Cohn, & Bajaj-Luthra, 1999).

A final issue we addressed in this study was the examination of the influence of stimulus characteristics (i.e., valence and intensity) on the facially modulated components of emotional systems. When participants produced Duchenne smiles only, a stronger facial effect was predicted for positive versus negative scenes. As expected, a congruent effect between Duchenne smiling and emotion-eliciting events was clearly supported for self-reported emotional experience and, partly, for autonomic nervous system reactivity. This effect was already postulated by a number of authors who hypothesized that adding congruent cognition (e.g., attention processes, semantic information) to expressive behaviors would provide a potent procedure for testing the modulating function of facial patterns (e.g., Izard, 1990). Thus, one may hypothesize that powerful feedback effects would depend on the interaction of muscular action patterns with congruent contextual and cognitive factors. It is interesting that research on mood congruence, which investigates the influence of affective state on memory, also provides empirical evidence in favor of this hypothesis. For instance, people exposed to a pleasant smell recalled more happy memories than did people exposed to an unpleasant smell (Ehrlichman & Halpern, 1988). So, it is likely that congruence between the hedonic valence of eliciting events and the self-generated cues (e.g., semantic information in memory, sensory feedback from the face) contribute to bias the subsequent response (e.g., retrieval, self-report measure of emotion experience, autonomic measures). One speculative hypothesis that could account for these findings would be that cognitively mediated positive experience (i.e., perception and appraisal of stimuli) and sensory feedback processes (e.g., via proprioceptive or cutaneous impulses) activate common neural pathways involved in the integrated experiential and autonomic output (e.g., cortico-limbic network).

Concerning the contribution of the intensity dimension of eliciting events in the facial modulation of emotion, a greater facilitating effect during the presentation of strongly positive videoclips was expected. This hypothesis was not confirmed because Duchenne smiling effects for emotional experience and psychophysiological measures did not differentiate between mildly and strongly positive videoclips. Concerning our failure to find subjective and autonomic differences between the smiling groups while participants were shown Cartoon 2, no clear explanation can be proposed. However, it can be noted that this videoclip induced the strongest positive experience in both the stimulus selection and testing procedures. Thus, a ceiling effect cannot be completely ruled out. This assumption would be consistent with the view that when funny videoclips evoke extreme or very strong positive experience, facial feedback would be less powerful to produce significant changes. Further research is needed to examine whether the facial feedback effect of smiling varies as a function of the intensity of positive experience (e.g., amusement feeling).

In the present study, a number of methodological issues were taken into account, including partialling out possible confounds (i.e., unpleasantness and difficulty of the pencil-holding tasks). Furthermore, it was demonstrated that the slight unpleasantness generated by the pencil-holding procedure was not a direct function of the type of facial configuration displayed. Thus, it is unlikely that emotional ratings were contaminated by differences between the pencil-holding techniques. In addition, as the muscular effort due to the difficulty of the task appeared to be at the same level in the five experimental groups, it is also unlikely that the observed subjective and autonomic changes were produced by muscular effort alone. This is corroborated by the lack of significant correlations between emotional ratings and task difficulty on the one hand, and emotional ratings and task unpleasantness on the other hand. Finally, the cardiac–somatic coupling usually invoked did not seem to be a critical factor of variation because the levels of facial activity generated by the pencil holding did not produce heart rate acceleration when the emotional stimuli were absent.

Some speculative propositions about the putative mechanism involved in the facial feedback effects reported in this study can be proposed. Because the experimental paradigm used in this research rules out mechanisms based on cognitive processes (e.g., self-perception, compliance with experimental demand), it is possible that physiologically driven mechanisms (e.g., muscular proprioceptive patterns, cutaneous sensation) mediate the observed effects. Available electrophysiological data in humans showed that mechanoreceptors of the facial skin respond to the deformation associated with lip and jaw movements, suggesting that facial movements may provide proprioceptive information (Johansson, Trulsson, Olson, & Abbs, 1988). Therefore, it is likely that sensory input generated by Duchenne smiling was automatically and rapidly processed outside conscious cognitive mediation. This afferent information may, then, contribute to the on-line modulation of the cognitively integrated emotional experience resulting from the perception of eliciting events. Although the neural substrate of this mechanism is not clearly understood, some structures such as somatosensory cortices have been proposed to account for the processing of facial and bodily cues involved in the experience of emotional state (Damasio, 1995; Damasio et al., 2000).

Finally, limitations in generalizability of our data must be acknowledged because our sample was composed of female participants only. Although research has not systematically addressed the issue of gender difference in facial feedback mechanisms, much research found effects in mixed-gender samples (see McIntosh, 1996). Further research is required to determine whether the facilitating effect of Duchenne smiling varies as a function of gender.

In conclusion, the findings of the present research suggest that the sensory input provided by Duchenne smiling contribute to the formation of positive feelings and, to some extent, to autonomic nervous system responsiveness. This was observed when participants focused their attention on pleasant and funny events. Additional research, of course, is needed to further explore the factors and mechanisms involved in the facial feedback effects. It would be particularly important to design unobtrusive paradigms that could be applied to the study of facial configurations representing other valid analogs of emotion.

References

Adelmann, P. K., & Zajonc, R. (1989). Facial efference and the experience of emotion. *Annual Review of Psychology, 40,* 249–280.

Boiten, F. (1996). Autonomic response patterns during voluntary facial action. *Psychophysiology, 33,* 123–131.

Buck, R. (1980). Nonverbal behavior and the theory of emotion: The facial feedback hypothesis. *Journal of Personality and Social Psychology, 38,* 811–824.

Cacioppo, J. T., Bush, L. K., & Tassinary, L. G. (1992). Microexpressive facial actions as a function of affective stimuli: Replication and extension. *Journal of Personality and Social Psychology, 18,* 515–526.

Cacioppo, J. T., Klein, D. J., Berntson, G. G., & Hatfield, E. (1993). The psychophysiology of emotion. In M. Lewis & J. M. Haviland (Eds.), *Handbook of emotions* (pp. 119–142). New York: Guilford Press.

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.

Chart (Version 3.5.2) [Computer software]. (1996). Castle Hill, New South Wales, Australia: ADInstruments Pty Ltd.

Cohen, J. (1988). *Statistical power analysis for behavioral sciences* (2nd ed.). New York: Academic Press.

Colby, C. Z., Lanzetta, J. T., & Kleck, R. E. (1977). Effects of the expression of pain on autonomic and pain tolerance responses to subject-controlled pain. *Psychophysiology, 14,* 537–540.

Damasio, A. A. (1995). Toward a neurobiology of emotion and feeling: Operational concepts and hypotheses. *The Neuroscientist, 1,* 19–25.

Damasio, A. R., Grabowski, T. J., Bechara, A., Damasio, H., Ponto, L., Pervizi, J., & Hichwa, R. D. (2000). Subcortical and cortical brain activity during the feeling of self-generated emotions. *Nature Neuroscience, 3,* 1049–1056.

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

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

Dickson, K. L., Walker, H., & Fogel, A. (1997). The relationship between smile type and play type during parent–infant play. *Developmental Psychology, 33,* 925–933.

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

Duchenne, G. B. (1990). *The mechanism of human facial expression or an electro-physiological analysis of the expression of emotions* (R. A. Cutherbertson, Ed. & Trans.). New York: Cambridge University Press. (Original work published 1862)

Duclos, S. E., & Laird, J. D. (2001). The deliberate control of emotional experience through control of expressions. *Cognition and Emotion, 15,* 27–56.

Duclos, S. E., Laird, J. D., Schneider, E., Sexter, M., Stern, L., & Van Lighten, O. (1989). Emotion-specific effects of facial expressions and postures on emotional experience. *Journal of Personality and Social Psychology, 57,* 100–108.

Ehrlichman, H., & Halpern, J. N. (1988). Affect and memory: Effects of pleasant and unpleasant odors on retrieval of happy and unhappy memories. *Journal of Personality and Social Psychology, 55,* 769–779.

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

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

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

Ekman, P., & Friesen, W. V. (1978). *Facial Action Coding System: A technique for measurement of facial movement.* Palo Alto, CA: Consulting Psychologist Press.

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

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

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

Ekman, P., Levenson, R. W., & Friesen, W. V. (1983, September 16). Autonomic nervous system activity distinguishes among emotions. *Science, 221,* 1208–1210.

Fernández-Dols, J. M., & Ruiz-Belda, M. A. (1995). Are smiles a sign of happiness? Gold medal winners at the Olympic Games. *Journal of Personality and Social Psychology, 69,* 1113–1119.

Fernández-Dols, J. M., & Ruiz-Belda, M. A. (1997). Spontaneous facial behavior during intense emotional episodes: Artistic truth and optical truth. In J. A. Russel & J. M. Fernández-Dols (Eds.), *The psychology of facial expression* (pp. 255–274). New York: Cambridge University Press.

Flack, W. F., Laird, J. D., & Cavallaro, L. A. (1999). Separate and combined effects of facial expressions and bodily postures on emotional feelings. *European Journal of Social Psychology, 29,* 203–217.

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

Frank, M. G., Ekman, P., & Friesen, W. V. (1993). Behavioral markers and recognizability of the smile of enjoyment. *Journal of Personality and Social Psychology, 64,* 83–93.

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

Fridlund, A. J. (1994). *Human facial expression: An evolutionary view.* San Diego, CA: Academic Press.

Gavanski, I. (1986). Differential sensitivity of humor ratings and mirth responses to cognitive and affective components of the humor response. *Journal of Personality and Social Psychology, 51,* 209–214.

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

Gross, J. J., & Levenson, R. W. (1997). Hiding feelings: The acute effects of inhibiting negative and positive emotion. *Journal of Personality and Social Psychology, 106,* 95–103.

Hager, J. C., & Ekman, P. (1981). Methodological problems in Tourangeau and Ellsworth's study of facial expression and experience of emotion. *Journal of Personality and Social Psychology, 40,* 358–362.

Hess, U., Kappas, A., McHugo, G. J., Lanzetta, J. T., & Kleck, R. E. (1992). The facilitative effect of facial expression on the self-generation of emotion. *International Journal of Psychophysiology, 12,* 251–265.

Howel, D. C. (1992). *Statistical methods for psychology* (3rd ed.). Belmont, CA: Duxbury Press.

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

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

James, W. (1890). *The principles of psychology,* New York: Holt.

Johansson, R. S., Trulsson, M., Olson, K. A., & Abbs, J. H. (1988). Mechanoreceptive afferent activity in the infraorbital nerve in man during speech and chewing movements. *Experimental Brain Research, 72,* 1209–1214.

Keltner, D. (1995). Signs of appeasement: Evidence for the distinct displays of embarrassment, amusement, and shame. *Journal of Personality and Social Psychology, 68,* 441–454.

Kleck, R. E., Vaughan, R. C., Cartwright-Smith, J., Vaughan, K. B., Colby, C. Z., & Lanzetta, J. T. (1976). Effects of being observed on expressive, subjective, and physiological responses to painful stimuli. *Journal of Personality and Social Psychology, 34,* 1211–1218.

Kraut, R. E. (1982). Social pressure, facial feedback, and emotion. *Journal of Personality and Social Psychology, 42,* 853–863.

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.

Lafrance, M., & Hecht, M. A. (1999). Option or obligation to smile: The effects of power and gender on facial expression. In P. Philippot, R. S. Feldman, & E. J. Coats (Eds.), *The social context of nonverbal behavior* (pp. 45–70). New York: Cambridge University Press.

Laird, J. D. (1974). Self-attribution of emotion: The effects of expressive behavior on the quality of emotional experience. *Journal of Personality and Social Psychology, 29,* 475–486.

Laird, J. D. (1984). The real role of facial response in the experience of emotion: A reply to Tourangeau and Ellsworth, and others. *Journal of Personality and Social Psychology, 47,* 909–917.

Lanzetta, J. T., Cartwright-Smith, J., & Kleck, R. E. (1976). Effects of nonverbal dissimulation on emotional experience and autonomic arousal. *Journal of Personality and Social Psychology, 33*, 354–370.

Larsen, R. J., Kasimatis, M., & Frey, K. (1992). Facilitating the furrowed brow: An unobtrusive test of the facial feedback hypothesis applied to unpleasant affect. *Cognition and Emotion, 6,* 321–338.

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

Levenson, R. W., Ekman, P., Heider, K., & Friesen, W. V. (1992). Emotion and autonomic nervous system activity in the Minangkabau of West Sumatra. *Journal of Personality and Social Psychology, 62,* 972–988.

Leventhal, H., & Mace, W. (1970). The effect of laughter on evaluation of a slapstick movie. *Journal of Personality, 38,* 16–30.

Manstead, A. S. R. (1988). The role of facial movement in emotion. In H. L. Wagner (Ed.), *Social psychophysiology: Theory and clinical applications* (pp. 105–129). New York: Wiley.

Matsumoto, D. (1987). The role of facial response in the experience of emotion: More methodological problems and a meta-analysis. *Journal of Personality and Social Psychology, 52,* 769–774.

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.

McIntosh, D. N. (1996). Facial feedback hypotheses: Evidence, implications, and directions. *Motivation and Emotion, 20,* 121–147.

McIntosh, D. N., Zajonc, R. B., Vig, P. S., & Emerick, S. W. (1997). Facial movement, breathing, temperature, and affect: Implications of the vascular theory of emotion efference. *Cognition and Emotion, 11,* 171–195.

Messinger, D. S., Fogel, A., & Dickson, K. L. (2001). All smiles are positive, but some smiles are more positive than others. *Developmental Psychology, 37,* 642–653.

Provine, R. R., & Fischer, K. R. (1989). Laughing, smiling, and talking: Relation to sleeping and social context in humans. *Ethology, 83,* 295–305.

Putnam, L., Winton, W., & Krauss, R. (1982). Effects of nonverbal affective dissimulation on phasic autonomic and facial responses. *Psychophysiology, 19,* 580–581.

Rutledge, L. L., & Hupka, R. B. (1985). The facial feedback hypothesis: Methodological concerns and new supporting evidence. *Motivation and Emotion, 9,* 219–240.

Schneider, K., & Unzner, L. (1989). Achievement-related cognitions and emotions in preschoolers. In F. Halisch & J. H. L. Van den Bercken (Eds.), *International perspectives on achievement and task motivation* (pp. 87–111), Amsterdam, the Netherlands: Swets & Zeitlinger.

Soussignan, R., & Schaal, B. (1996a). Children's facial responsiveness to odors: Influences of odor valence, gender, age, and social presence. *Developmental Psychology, 32,* 367–379.

Soussignan, R., & Schaal, B. (1996b). Forms and social signal value of smiles associated with pleasant and unpleasant sensory experience. *Ethology, 102,* 1020–1041.

Strack, F., Martin, L. L., & Stepper, S. (1988). Inhibiting and facilitating conditions of the human smile: A nonobstrusive test of the facial feedback hypothesis. *Journal of Personality and Social Psychology, 54,* 768–777.

Surakka, V., & Hietanen, J. K. (1998). Facial and emotional reactions to Duchenne and non-Duchenne smiles. *International Journal of Psychophysiology, 29,* 23–33.

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

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.

VanSwearingen, J. M., Cohn, J. F., & Bajaj-Luthra, A. (1999). Specific impairment of smiling increases the severity of depressive symptoms in patients with facial neuromuscular disorders. *Aesthetic Plastic Surgery, 23,* 416–423.

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

Winton, W. M. (1986). The role of facial response in self-reports of emotion: A critique of Laird. *Journal of Personality and Social Psychology, 50,* 808–812.

Zajonc, R. B., Murphy, S. T., & Inglehart, M. (1989). Feeling and facial efference: Implications of the vascular theory of emotion. *Psychological Review, 96,* 395–416.

Zuckerman, M., Klorman, R., Larrance, D., & Spiegel, N. (1981). Facial, autonomic, and subjective components of emotion: The facial feedback hypothesis versus the externalizer–internalizer distinction. *Journal of Personality and Social Psychology, 41,* 929–944.

Received March 5, 2001
Revision received December 6, 2001
Accepted December 6, 2001 ■