Journal of Personality and Social Psychology
1992, Vol. 62, No. 6, 972–988

0022-3514/92/$3.00

Emotion and Autonomic Nervous System Activity in the Minangkabau of West Sumatra

Robert W. Levenson
University of California, Berkeley

Paul Ekman
University of California, San Francisco

Karl Heider
University of South Carolina

Wallace V. Friesen
University of California, San Francisco

Physiology and emotional experience were studied in the Minangkabau of West Sumatra, a matrilineal, Moslem, agrarian culture with strong proscriptions against public displays of negative emotion. Forty-six Minangkabau men were instructed to contract facial muscles into prototypical configurations of 5 emotions. In comparison with a group of 62 Ss from the United States, cross-cultural consistencies were found in (a) autonomic nervous system (ANS) differences between emotions and (b) high configuration quality being associated with increased ANS differentiation and increased report of emotional experience. These findings provide the first evidence that these patterns of emotion-specific ANS activity and the capacity of voluntary facial action to generate this activity are not unique to American culture.

In a series of experiments using American subjects (Ekman, Levenson, & Friesen, 1983; Levenson, Carstensen, Friesen, & Ekman, 1991; Levenson, Ekman, & Friesen, 1990), we found evidence for differences in autonomic nervous system (ANS) activity among emotions such as anger, disgust, fear, happiness, and sadness. In these experiments, ANS responses were primarily elicited using a Directed Facial Action task. In this task, subjects were given instructions to voluntarily contract certain facial muscles, resulting in facial configurations that involve contraction of the same facial muscles as in facial expressions thought to signal emotions universally (Ekman, 1972; Ekman & Friesen, 1971; Ekman, Sorenson, & Friesen, 1969; Izard, 1971; see Ekman, 1989, for a review of this evidence).

Patterns of emotion-specific ANS activity produced by voluntary facial actions were found to be consistent for actors and college students and for men and women (Levenson et al., 1990). Compared with young subjects in their reproductive prime, similar patterns were found for very old subjects (age 71–83), although the magnitude of ANS change was smaller for older subjects (Levenson et al., 1991).

A number of possible mediators that could account for the generation of emotion-specific ANS activity by voluntary facial action were evaluated and rejected. These included: (a) visual feedback of facial expressions (in a mirror or on the face of a coach); (b) differences in the amount of facial muscle activity required to make the different emotional configurations; (c) differences in the amount of concomitant activity of nonfacial muscles; and (d) differences in the difficulty of making the different configurations (Levenson et al., 1990).

Are These Findings Unique to American Culture?

Emotion-Specific ANS Activity

We hypothesized that the same ANS differences among emotions exist in all cultures. This is in keeping with our view that the connections among different aspects of emotion (antecedent conditions, facial expression, vocalization, and ANS activity) are evolved phenomena, having been established through natural selection so the organism can respond most efficiently to certain prototypical environmental demands. As an alternative, the social-constructionist view of emotion (e.g., Averill, 1980; Lutz, 1988) could be extended to posit that these connections result from species-specific learning and thus could be learned in a culturally variable way. As for the ANS, its capacity for learning has been well established; starting with Pavlov, ANS responses have been associated with a wide range of antecedent stimulus conditions by means of classical conditioning.

In contrast to emotional facial expressions, for which considerable evidence for cross-cultural consistency has been reported (e.g., Ekman, 1972, 1989; Ekman & Friesen, 1971; Ekman, Sorenson, & Friesen, 1969; Izard, 1971), and to antecedent conditions for emotion, for which some evidence for cross-cultural consistency has also been reported (e.g., Boucher, 1983; Boucher & Brandt, 1981; Scherer, Wallbott, & Summerfield, 1983), we are aware of no studies that have examined cross-cultural consistency in the ANS activity that accompanies specific emotions.[1]

This research was supported by National Institute of Mental Health (NIMH) Grant MH39895 and National Institute on Aging Grant AG07476 to Robert W. Levenson, NIMH Grant MH38691 and Research Scientist Award MH06092 to Paul Ekman, and NIMH Grant MH38221 to Karl Heider.

Correspondence concerning this article should be addressed to Robert W. Levenson, Department of Psychology, University of California, Berkeley, California 94720.

[1] Although several cross-cultural studies with some relevance to emotion and physiology exist, none have compared ANS patterning

Generation of Emotion-Specific ANS Activity by Directed Facial Action

As with ANS differences among emotions, the capacity of voluntary facial action to generate emotion-specific ANS activity could also be universal or culturally variable. Here again, we hypothesized universality in keeping with our view that there is a "hard-wired"[2] basis for this generation (Ekman, 1984, in press; Ekman et al., 1983; Levenson et al., 1990). An alternative view might posit that the basis for this association derives from the associations that are formed between *involuntary* facial actions and patterns of ANS activity that cooccur in naturally occurring emotion. By stimulus generalization, the *voluntary* representation of the facial expression could develop the capacity to activate the other associated element. We believe that this kind of learned connection would be quite susceptible to cultural variation due to cultural display rules (Ekman & Friesen, 1969, 1975). For example, if, in a given culture, the display rule was such that one should not allow others to know when one is angry and thus should not show angry facial expressions, there would be fewer "learning trials" for establishing the association between the facial expression of anger and the ANS changes associated with anger.

Just as there have been no studies of cross-cultural consistency in the ANS patterns that accompany specific emotions, there have been no studies of the capacity of directed facial actions to produce such patterned activity in different cultures.

Generation of Subjective Emotional Experience by Directed Facial Action

Here we hypothesized that cross-cultural variation would be more likely than cross-cultural consistency. Our experience with the Directed Facial Action task suggests that the capacity of voluntary facial actions to generate subjective emotional experience is the least robust aspect of our findings, showing considerable variation from experiment to experiment (Levenson et al., 1990) and varying as a function of subjects' age (Levenson et al., 1991). We expected that the reporting of actual emotional experience is vulnerable to cultural differences in the salience given to different kinds of cues and in the criteria used to label a state as *emotion.*

The Minangkabau of West Sumatra

Minangkabau Culture

Ideally, cultural influences on the relations among expressive, subjective, and physiological aspects of emotion should be studied in a large number of settings; however, we were able to study only a single culture. To provide the strongest possible test of our hypotheses, we sought a culture that differed from ours in as many ways as possible, but, most important, in its beliefs concerning emotion and emotional expression. For logistic reasons, this culture had to be accessible to outside researchers and to have resources that would enable us to obtain both video and electrophysiological data (e.g., a source of electrical power). The Minangkabau culture of West Sumatra met these requirements.

Sumatra is a large island (1,760 km long by 400 km wide) in western Indonesia. Although not as densely populated as Java, it contains several large and distinct cultural groups. One of these, the Minangkabau, traces back to at least the 12th century. They are an old, high culture of about 2½ million people living in West Sumatra and another 2 million people living outside the province. Famous in the anthropological literature as the world's largest matrilineal society, they are also strong Moslems. The tensions between their strongly female-orientated socioeconomic organization and their fiercely male-oriented religion have long fascinated scholars (e.g., Abdullah, 1966).

Prominent architectural features of this culture are large rectangular houses built on pilings several meters off the ground with distinctive saddle-shaped roofs. In the old matrilineal agrarian society, mothers, daughters, and daughters' families lived together in these houses. Before puberty, young unmarried boys went to live separately in communal houses until wed, at which time they went to live in the house of their wife's mother. More recently, economic and social changes have produced movement toward less extended, more nuclear family living arrangements (Kato, 1982).

A cultural center of the Minangkabau is the small city of Bukittinggi, which is located in the mountains (elevation 915 m) about 100 km from Padang, the capital and main seaport of West Sumatra. The high valleys of the Minangkabau heartland have rich volcanic soils and support a highly diverse agriculture, which, along with mining and commerce, make up the major features of the local economy.

In 1983–1984, Heider spent a year in Bukittinggi studying Minangkabau emotional behavior. He returned in July, 1985, for another year of fieldwork. Ekman and Levenson joined him

during different emotions in different cultures. For example, *self-reports* of ANS responses were compared during embarrassment between Japanese and British college students (Edelmann & Iwawaki, 1987) and during anxiety-provoking situations between Japanese and Swedish teenagers (Magnusson, Stattin, & Saburo, 1983). Studies actually obtaining physiological measures included comparison of urinary catecholamines in subgroups of Filipino-Americans who varied in their contact with urban Hawaiian culture (Brown, 1982); comparison of the skin conductance responses to a stressful film (*Subincision*) between Japanese college students, well-educated Japanese adults, and American college students (Lazarus, Opton, Tomita, & Kodama, 1966); and comparisons of Japanese and Western electrocortical responses to emotional sounds (Tsunoda, 1979).

[2] We have speculated that this hard-wired connection could be between areas of motor cortex that are responsible for the generation of emotional facial expression and hypothalamic centers that are responsible for the control of ANS activity. Whereas this hypothesis is highly speculative, the existence of connections between motor cortex and sympathetic nervous system functions has been well established by research that has (a) electrically stimulated the motor cortex and examined autonomic responses (e.g., Clarke, Smith, & Shearn, 1968; Delgado, 1960; Eliasson, Lindgren, & Uvnas, 1952; Green & Hoff, 1937; Hsu, Hwang, & Chu, 1942; Wall & Pribram, 1950); (b) ablated the motor cortex and examined ANS responses (e.g., Fulton, 1949; Kennard, 1937); and (c) stimulated ANS afferent nerves and examined evoked potentials in motor cortex (e.g., Thompson, Lerner, Fields, & Blackwelder, 1980). Directly paralleling our speculations, Spiegal and Hunsicker (1936) suggested that it was hypothalamic projections that were partially responsible for mediating this motor cortex–ANS relationship, but there has never been an empirical test of this notion.

there in March, 1986, to conduct several studies of the nature of emotional expression, subjective experience, and physiology in the Minangkabau culture. By that time Heider was sufficiently fluent in the Minangkabau and Indonesian languages and had made sufficient personal contacts to make it feasible for us to consider carrying out "laboratory" studies of emotion in this setting.

Emotion in Minangkabau Culture

Heider's ethnographic studies revealed that Indonesian cultures in general provide a strong contrast to Western cultures in the ways in which they deal with emotion (Heider, 1984, 1991a, 1991b). In comparison with Americans, for whom the internal experience of emotion is very important, Minangkabau more commonly emphasize the external aspects of emotion, focusing primarily on the implications of emotion for interpersonal interactions and relationships (a similar focus has been noted by Lutz, 1982, for the Ifaluk of Micronesia and in other Asian cultures). Although Minangkabau can talk about internal feelings and, thus, could answer questions we posed about their feelings, Heider's evidence suggests that for most emotions, they are much less interested in and involved with this aspect of emotion than are Westerners.

Two other aspects of Heider's work were relevant to the present study. First, he was investigating the hypothesis that Minangkabau are socialized to diminish or mask strong negative emotional displays (especially anger) to a much greater extent than Westerners. If this hypothesized display rule proved to be true, it could result in Minangkabau having fewer opportunities to learn relations among subjective, expressive, and physiological aspects of the negative emotions; and this would especially be the case for anger. Second, he had undertaken a thorough lexical mapping of emotion words in Indonesian and Minangkabau languages (Heider, 1991b). Because all of our interactions with subjects would be conducted in these languages, having an accurate emotional lexicon was critical both to our giving instructions to subjects and to our understanding their verbal responses.

Method

Subjects

Minangkabau. Our research team consisted of three American men; cultural constraints regarding contact between men and women limited us to studying only male subjects. Using local assistants, we recruited 129 young Minangkabau men (age 16–27) living in or near the town of Bukittinggi, West Sumatra. As has been our practice with Western subjects, recruits attended brief individual screening sessions to determine whether they could voluntarily move selected facial muscles. Subjects were paid the equivalent of $5 for this screening session. Fifty subjects evidencing good voluntary control were scheduled for an experimental session within the next few days, for which they were paid the equivalent of $15. Usable data were obtained from 46 subjects. Data loss that did occur was due to procedural errors, interruptions in electrical power, noise produced by heavy rains (making it impossible to deliver verbal instructions in our tin-roofed building), or loss of videotapes.

Americans. To provide a comparison sample, we used data from a recently published set of three experiments (Levenson et al., 1990), which provided a diverse sampling of young American subjects. One of these experiments was conducted in Bloomington, Indiana, using college students, whereas the other two were conducted in San Francisco, California, using students and nonstudents. There were 62 young subjects (27 men and 35 women, ages 18–30) in these experiments, all of whom were paid for their participation (payments ranged from $10 to $25).

Some mention should be made of our rationale for using this particular comparison group instead of attempting to construct an American sample matched to the Minangkabau sample on certain variables. In contrast with this diverse sample of 62 Americans, a matched comparison group using available data would have been much smaller (thus unfairly working in favor of our finding no cultural differences) and would have provided a less representative sampling of American culture. In addition, because we had used this same comparison group in our recent study of the Directed Facial Action and Relived Emotion tasks in old American subjects (Levenson et al., 1991), an opportunity for establishing a common point of comparison was available. One obvious way to create a more matched group would have been to limit the comparison sample to men; however, we had found no relevant sex differences in previous work with this sample (Levenson et al., 1990, 1991). Nonetheless, critical data analyses were repeated using a comparison sample composed only of male subjects.

Apparatus

Nonphysiological. Our "laboratory" was constructed in a large 4 m × 5 m room and a small adjoining room. We divided the large room diagonally using white bed sheets hanging from ropes nailed to the walls. The subject was seated in a chair in the corner of the room on one side of the sheets. A small table was located in front of the subject. On the other side of the divider were two battery-operated Panasonic AG-100 camcorders mounted on tripods. The camcorders recorded subjects' facial behavior through small holes cut in the sheets. Also on this side, Ekman and Heider sat at a small table and could see the subject's face on a small portable television monitor connected to one of the camcorders. Except during heavy rains, the room was small enough to enable normal conversation with the subject without additional amplification. An audio mixer was used to combine signals from (a) a lavaliere microphone that recorded the subject's verbal responses, (b) a microphone that recorded the experimenters' instructions, and (c) a device that generated a synchronization tone that was recorded on the audio track of the video recording at the start of each trial.

Levenson sat in the adjoining room at a table that held the physiological recording equipment and a second portable television monitor connected to the second camcorder. The setup enabled visual communication among the three experimenters (which was necessary for coordinating the experimental procedures) and observation of the subject on the television monitors. The subject, however, could not see any of the experimenters after the experiment was underway.

Physiological. Physiological recording equipment had to be specially designed for this project. Electrical power was available, but it was often interrupted and not well regulated as to voltage or frequency (an uninterruptible power supply provided some protection against interruptions of short duration). A miniaturized portable polygraph was designed and built to our specifications by Lafayette Instruments.[3]

The polygraph enabled us to measure five channels of physiological information, which yielded seven measures:

1. *Heart rate* (measured as the cardiac interbeat interval). The elec-

[3] We wish to express our gratitude to Vern E. Davidson of Lafayette Instruments for his help in designing and constructing this equipment.

trocardiogram was obtained using Beckman miniature electrodes attached to either side of the chest with adhesive collars, with a ground electrode in a spring-loaded clip placed on the right earlobe. Omniprep was used to prepare the skin and Beckman electrode paste was used as the electrolyte. The amplifier was capacitor coupled with a time constant of .16 s. The interbeat interval was quantified as the time interval between successive R-waves.

2. *Finger temperature.* A Yellow Springs Instruments thermistor was attached to the palmar surface of the first phalange of the middle finger of the dominant hand with surgical tape. The thermistor was direct coupled into a circuit that enabled determination of temperature in degrees Fahrenheit. Calibration was accomplished using an internal circuit that introduced the equivalent of a 1 °F change in temperature.

3. *Skin conductance.* A constant voltage system was used with Beckman regular electrodes attached with adhesive collars to the palmar surface of the second phalanges of the first and third fingers of the nondominant hand. Sodium chloride in Unibase was used as the electrolyte. The signal was direct coupled into a circuit that enabled determination of conductance in μmhos. Calibration was accomplished using an internal circuit that introduced the equivalent of a .5 μmho change in conductance.

4 and 5. *Finger pulse transmission time and finger pulse amplitude.* A UFI infrared reflective photoplethysmograph was attached to the palmar surface of the middle finger of the nondominant hand using velcro tape. This device detected the pulse pressure wave at the finger. The plethysmograph signal was capacitor coupled into an amplifier with a time constant of .1 s. Finger pulse transmission time was quantified as the time interval between the R-wave of the electrocardiogram and the beginning of the upstroke of the pulse pressure wave at the finger. Finger pulse amplitude was quantified as the peak-to-trough amplitude of the pulse pressure wave in mV of signal.

6 and 7. *Respiratory period and respiratory depth.* A pneumatic bellows was attached around the upper abdomen using a metal chain and clasp. The bellows was attached to a pressure transducer, and the resultant signal was direct coupled into an amplifier on the polygraph. The time interval between the start of successive inspirations and the amplitude between the peak of inspiration and the peak of expiration were measured. Respiratory depth could not be calibrated between subjects and thus was quantified in arbitrary units (which were consistent across trials within subjects).

These physiological measures were selected to sample major ANS functions (i.e., cardiac, vascular, thermoregulatory, respiratory, and electrodermal) and to include the measures (heart rate, skin conductance, and finger temperature) that we had found previously to differentiate emotions in American subjects (Ekman et al., 1983; Levenson et al., 1990, 1991).

Cables carrying the signals from the subject were routed to the adjoining room where they were connected to the polygraph. The electrical output of the polygraph was connected to five channels of a Vetter C-8 FM recorder, which recorded the raw signals on standard audiocassettes. A sixth channel was used to record a synchronization pulse generated at the start of each trial by the same device that generated the synchronization tone that was recorded on the audio channel of the video recording. The remaining channels of the FM recorder were used to record the output of a microphone into which Levenson dictated a running account of all polygraph balance and sensitivity settings at the start of each trial and any changes in settings at the moment they were made during each trial.

As it turned out, these audiocassettes provided the only complete permanent record of the physiological data. We had planned to obtain a backup record of all signals on the polygraph chart paper. Unfortunately, large humidity swings, which occurred almost daily, caused the chart paper to curl and jam, periodically making the paper record unusable. A miniature two-channel Nonlinear Systems oscilloscope, which was brought along to aid in equipment maintenance, was pressed into service. By switching the oscilloscope among channels, we were able to continue on-line monitoring of physiological signal quality whenever the chart drive jammed.

Procedure

After subjects arrived, the procedures were described to them in Indonesian by Heider. Transducers for recording the physiological data were attached by Levenson, and the function of each was explained in simple terms by Heider. All 46 subjects began with the Directed Facial Action task. For half of the subjects, this was followed by the Relived Emotions task, in which emotional memories were recalled and reexperienced; and for the other half, this was followed by a film viewing task. The present report is limited to findings from the Directed Facial Action task.

The Directed Facial Action task was administered under two different conditions—with and without a mirror. When we started the experiment we had no way of knowing how many subjects we could test successfully and planned to test all subjects using a mirror, which was placed on the table in front of the subject and adjusted so that he could see his face. After we had successfully completed testing the first 28 subjects (which exceeded our most optimistic expectations), we decided to take advantage of the opportunity to try a mirror-versus-no-mirror condition in this culture. Thus, the remaining 18 subjects were tested in the exact same way but without the mirror.

The task began with Heider giving the subject the instructions in Indonesian for making the "standard control face," a facial configuration unrelated to emotion (cheeks puffed out gently, eyes closed). Each trial began with a 30-s rest period, then the subject was asked to make the standard control face and hold it for 10 s. After a 10-s rest, the subject was given muscle-by-muscle instructions for constructing an emotional facial configuration (the associated emotion was not mentioned).

For example, to construct the facial configuration for disgust, the subject would be asked in Indonesian[4] to (a) "wrinkle your nose and let your mouth open," (b) "pull your lower lip down," and (c) "move your tongue forward, but do not stick it out." These three instructions, if successfully followed, would contract the following muscles: (a) levator labii superioris and alaeque nasi in the middle face area (relaxation of masseter and of temporal and internal pterygoid in the jaw), (b) depressor labii in the lip, and (c) various lingual muscles.

Viewing the subject's face on the monitor, Ekman provided feedback and suggestions as needed. These suggestions were translated by Heider and relayed to the subject to help him comply with the instructions (e.g., "that's right," "don't raise your eyebrows, lower them," or "try to raise your eyelid higher"). The final facial configuration was held for 10 s.

The subject was then asked in Minangkabau if any emotions, memories, or physical sensations had occurred during the facial configuration.[5] For any emotions reported, the subject was asked to rate their

[4] In Indonesian, (a) "kerut kan hidung anda dan biarkan mulut anda terbuka"; (b) "tarik bibir bawah anda kebawah"; and (c) "gerakan lidih anda kemuka tetapi tidak terlu dikeluarkan."

[5] In Indonesian, "Parasaan, gajolak, ingatan apo nan sudaro alami?" Like most adult Minangkabau, these subjects were fluently bilingual in Indonesian and Minangkabau. Because Heider was more comfortable in Indonesian, preliminary conversation and facial movement instructions were conducted in Indonesian. However, subjects were asked to report their emotions, memories, and sensations in Minangkabau. Despite the relatively greater emphasis that Minangkabau place on interactional as compared with internal aspects of emotion, subjects appeared quite comfortable in using the rating scale and in responding to these questions.

intensity on a 0–8 scale, with 0 being no experience of that emotion and 8 being the most intense experience of that emotion in his life. Subjects were then asked to rate the difficulty of making the emotional configuration on a 0–8 scale. After a 2-min rest period, the next trial began.

This procedure was repeated for five[6] emotional configurations in one of two orders: (a) happiness, sadness, disgust, fear, and anger and (b) sadness, happiness, anger, fear, and disgust. Each configuration represented an emotional expression that, on the basis of evidence from cross-cultural studies of emotion was thought to be universal (Ekman, 1972, 1989; Ekman & Friesen, 1971; Ekman, Sorenson, & Friesen, 1969; Izard, 1971). Subjects were provided with only one opportunity to make each configuration.

Initial Data Reduction

After our return to the United States, the self-report data, video recordings, and physiological data all required fairly extensive processing before we could begin data analyses. The goal of this initial data reduction was to produce a Minangkabau data set that would be as comparable as possible in format, quality, and scope with previous data sets collected using the Directed Facial Action task in our laboratory in the United States.

Self-report data. Heider had asked subjects to use Minangkabau when giving their self-reports of emotions, memories, and physical sensations, but subjects occasionally responded in Indonesian. Heider translated these reports into English, using translation equivalents based on his research on Minangkabau and Indonesian emotion terms (Heider, 1991b).

Facial data. Time codes were added to the video recordings and then each trial was logged to locate the major events in relation to the synchronization tones recorded at the start of each trial. The instructed facial configurations were specified in terms of the Facial Action Coding System (FACS; Ekman & Friesen, 1978), which decomposes facial behavior into its component muscular actions. Working with a silent video recording, a rater assigned a performance score (using a 0–4 scale) to each facial configuration, indicating the extent to which (a) the configuration included all of the muscle contractions specified in the instructions and no others, and (b) the contractions were held steadily throughout the 10-s holding period.

Physiological data. Physiological data were reduced in several stages. The FM tape recording of each subject's raw physiological data was played back through DC-coupled channels of a Grass Model 7 polygraph into analog-to-digital conversion channels of a Digital Equipment Corporation PDP 11 minicomputer. The computer program that we used to collect data on-line in our domestic studies was modified for processing these prerecorded data. The resolution of the computer system was 1 ms for measures of time (i.e., heart rate, finger pulse transmission time, and respiration period) and 1 mV for measures of amplitude (i.e., skin conductance, finger temperature, finger pulse amplitude, and respiratory depth).

Listening to the running commentary recorded in Sumatra of the polygraph settings at the beginning of each trial and changes in those settings that occurred during the trial (e.g., adjustments of basal skin conductance level), each trial was "rehearsed" several times until the changes could be entered into the computer exactly as they had occurred in Sumatra. After a trial was processed in this way, visual examination of the new paper records that were created on the Grass polygraph enabled the usual kinds of data editing that are necessary with these kinds of psychophysiological recordings. Fortunately the quality of the recorded data was quite high and only minimal additional editing was needed.

All physiological data processing and editing was done completely blind as to the target emotion on a given trial and to the timing of the events on that trial (e.g., the point at which the subject was asked to hold the final configuration).

The output of this stage of the data reduction was continuous second-by-second averages of the seven physiological measures, all temporally referenced to the synchronization signals recorded at the start of each trial on the FM tapes and on the video recordings.

Using the timing information derived from logging the video recordings, we extracted and averaged physiological data during the time that the nonemotional facial configuration was held (10 s) and during the time that the emotional configuration was held (10 s) on each trial. We computed a change score for each physiological measure on each trial by subtracting the mean for the nonemotional configuration (i.e., the standard control configuration) on that trial from the mean for the emotional configuration on that trial. These procedures were identical to those used in our previous studies.

Results

Minangkabau Subjects: Physiological Data

Multivariate tests of emotion and order effects. A 2 × 5 (Order × Emotion) multivariate analysis of variance (MANOVA) was performed on Minangkabau data using heart rate, finger temperature, skin conductance, finger pulse transmission time, and finger pulse amplitude data.[7] This revealed a significant effect for emotion, $F(20, 18) = 2.49$, $p = .029$, indicating that physiological differences among emotions existed.

There were no differences related to the two experimental orders; both the order main effect, $F(5, 33) = .53$, and the Order × Emotion interaction, $F(20, 18) = 1.41$, were nonsignificant.

Univariate tests of differences among emotions. In our previous work with Americans, using the Directed Facial Action task (Levenson et al., 1990, 1991), autonomic distinctions among emotions were strongest when subjects produced facial configurations that most closely resembled the associated emotional expressions. In that work, a rating of 3 or greater on the 4-point quality scale (described earlier) was used as the cutoff. Because Minangkabau facial configurations were of significantly lower quality than those of the Americans (mean ratings: Minangkabau = 2.12; Americans = 2.69), $F(1, 105) = 23.70$, $p < .001$, the cutoff of 3 or greater would have reduced the number of usable trials for Minangkabau too severely. Thus, for all sub-

[6] In our previous studies we had used six emotional configurations but needed to shorten the Directed Facial Action task somewhat to allow more time for the second task (film viewing or Relived Emotions) without unduly fatiguing subjects. Surprise seemed to be the most reasonable emotion to omit, given that it had proved difficult to differentiate from the other emotions in our initial study (Ekman et al., 1983).

[7] The two respiratory variables had to be excluded from this MANOVA so as not to unduly reduce the number of cases analyzed. Because the period of respiratory cycles ranges from about 4 to 10 s, when means are derived for the 10-s period in which directed facial actions are held, missing data are much more likely than is the case with nonperiodic physiological variables (e.g., temperature) or those with shorter periods (e.g., heart rate). Most MANOVA programs drop any subject from the analysis who has a missing data value for *any* level of *any* repeated measure variable.

jects in the present study, both Minangkabau and American, we adopted a less stringent cutoff—a quality rating of 2 or greater. This left us with a minimum of 27 usable trials for each emotion for the Minangkabau. These data were analyzed using univariate 2 × 5 (Mirror × Emotion) analyses of variance (ANOVAs), with the degrees of freedom adjusted using the Huynh-Feldt epsilon when deviations from sphericity occurred (results pertaining to the mirror factor are presented later in this article).

Earlier, it was reported that an overall MANOVA revealed a significant main effect for emotion. Univariate ANOVAs revealed significant main effects for emotion for five of the seven measured physiological variables: (a) heart rate, $F(4, 112) = 5.11$, $p = .001$; (b) finger pulse transmission time, $F(4, 111) = 3.14$, $p = .017$; (c) finger pulse amplitude, $F(4, 111) = 3.69$, adjusted $p = .014$; (d) respiratory period, $F(4, 100) = 4.27$, adjusted $p = .006$; and (e) respiratory depth, $F(4, 100) = 3.31$, adjusted $p = .022$. When these analyses were repeated using all trials without regard to configuration quality, the emotion effect was significant for only four of the seven variables (the effect for finger amplitude was no longer significant).

Within these five significant emotion main effects, the nature of the physiological differentiation among the five emotional configurations was explored using planned pairwise comparisons. We established a rejection level of $p = .02$ for these comparisons using a modification of the Bonferroni procedure (Keppel, 1982).[8] Each of the five physiological measures produced a somewhat different set of distinctions among the emotions.

For heart rate, anger, fear, and sadness were associated with significantly larger heart rate accelerations than was disgust. The heart rate acceleration for happiness was intermediate—significantly smaller than that for anger.

For finger pulse transmission time, sadness was associated with significantly greater shortening of finger pulse transmission time than was disgust and happiness, with anger and fear in between, nonsignificantly differentiated from the other emotions.

For finger amplitude, sadness showed a significantly greater increase in pulse amplitude than did anger, disgust, or fear (the latter two emotions actually evidenced small decreases in pulse amplitude). Happiness was intermediate, nonsignificantly differentiated from the other emotions.

For respiratory period, fear and disgust were associated with significantly more shortening of respiratory period than happiness, with anger and sadness falling in between, nonsignificantly differentiated from the other emotions.

For respiratory depth, happiness was associated with significantly greater deepening of respiration than disgust, with anger, fear, and sadness falling in between, nonsignificantly differentiated from the other emotions.

Means and standard errors for Minangkabau high-quality facial configurations are presented in the top three panels of Figure 1 for heart rate, finger temperature, and skin conductance and in the top four panels of Figure 2 for finger pulse transmission time, finger pulse amplitude, respiration period, and respiration depth. A complete reporting of means and standard errors for all subjects (Minangkabau and American) can be found in Table 1.

Effects of using a mirror. A 2 × 5 (Mirror × Emotion) MANOVA was performed on Minangkabau data using heart rate, finger temperature, skin conductance, finger pulse transmission time, and finger pulse amplitude data. There were no differences related to the use of the mirror; both the mirror main effect, $F(5, 35) = 1.54$, and the Mirror × Emotion interaction, $F(20, 20) = 1.00$, were nonsignificant.

Univariate tests confirmed that the presence of the mirror had essentially no effect on physiological responding. The main effect for mirror was nonsignificant for all physiological variables except for finger temperature (mirror = .18 °F and no mirror = −.01 °F), $F(1, 44) = 8.03$, $p = .007$. The interaction of Mirror × Emotion was nonsignificant for all physiological variables.

Idiographic data analysis. An idiographic data analytic strategy used in our previous studies (Levenson et al., 1990, 1991) was also applied to the Minangkabau data. This idiographic approach has several advantages: (a) It avoids possible distortion of individual subjects' patterns of emotion-specific ANS activity resulting from averaging group data; (b) it is highly sensitive to small, albeit consistent, differences among emotions; and (c) it provides a single, easily interpretable metric of performance, which facilitates evaluation of the effects of different experimental conditions (e.g., presence vs. absence of mirror) and different subject samples (e.g., Minangkabau vs. American).

In our experiments with young American subjects (Levenson et al., 1990), we found four distinctions among negative emotions to be the most reliable:[9] (a) Heart rate acceleration was larger for anger than for disgust, (b) heart rate acceleration was larger for fear than for disgust, (c) heart rate acceleration was larger for sadness than for disgust, and (d) finger temperature increase was larger for anger than for fear. These same distinctions were also found in very old American subjects (Levenson et al., 1991).

The idiographic analysis was conducted by computing "hit rates" for each subject for each of the four distinctions. A "hit" was recorded whenever a distinction was found (e.g., that subject's heart rate was faster during the anger trial than during the disgust trial), regardless of how small the difference might be. Ties were counted as misses. Nonparametric tests were performed on the percentage of hits for each distinction, assuming a chance rate of 50%.

Differences among emotions in idiographic data. Figure 1 shows that Minangkabau group data for heart rate and finger temperature (Panels 1 and 2) were roughly consistent with all four of the distinctions among negative emotions found previ-

[8] In this procedure, the number of degrees of freedom associated with the treatment effect (i.e., 4 *dfs* for emotion) is considered to be the number of comparisons that would be allowed without correction. This number is multiplied by the rejection level and then divided by the number of comparisons that will be conducted (4 × .05/10 = .02).

[9] In these previous studies, distinctions could only be based on heart rate, finger temperature, skin conductance, and muscle activity, which were the four physiological measures common to all studies.

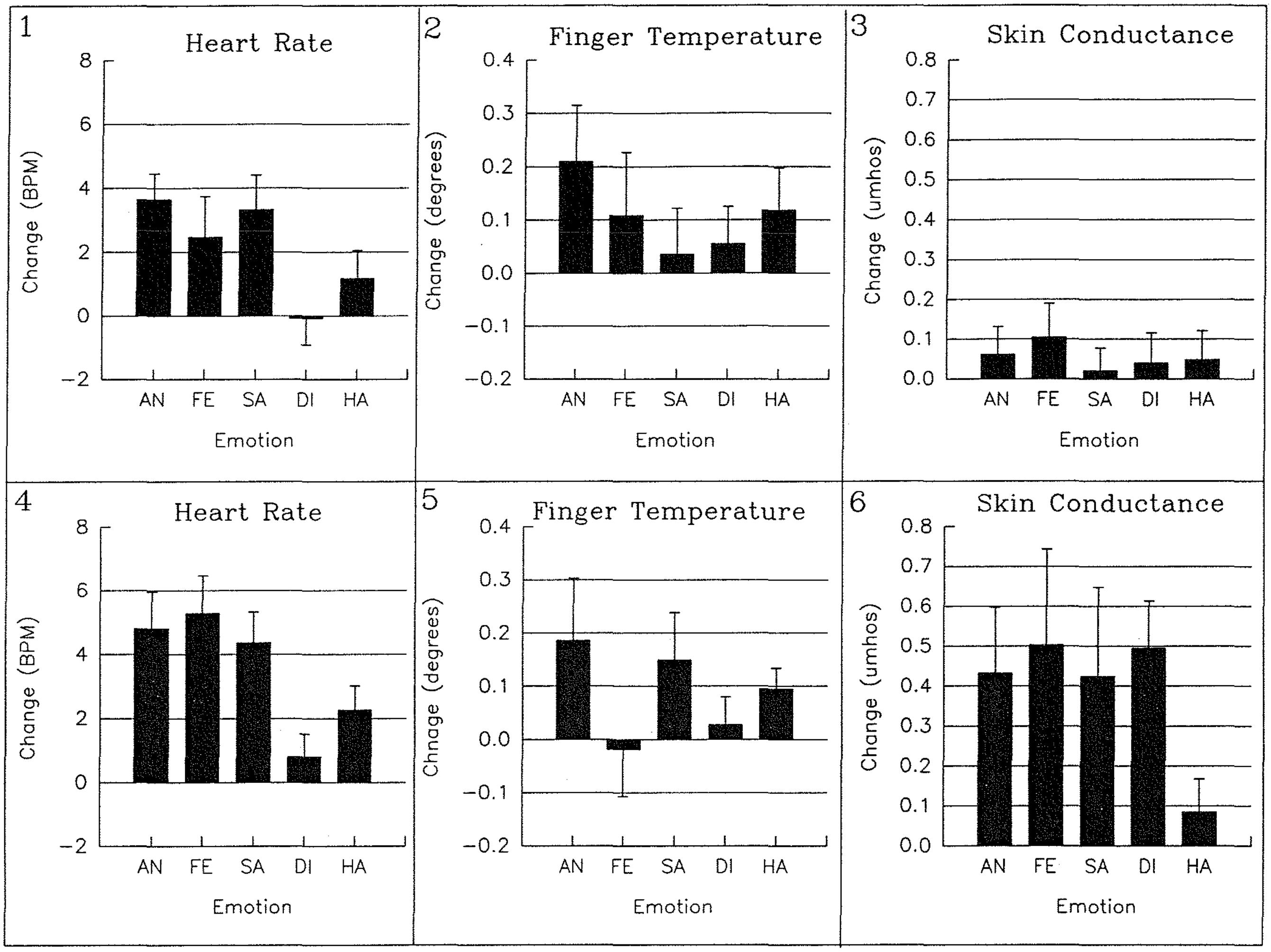

Figure 1. Minangkabau (Panels 1, 2, and 3) and American (Panels 4, 5, and 6) mean change and standard errors for heart rate (bpm = beats per minute), finger temperature, and skin conductance for high-quality configurations in Directed Facial Action task. AN = anger; FE = fear; SA = sadness; DI = disgust; HA = happiness.

ously in Americans, insofar as group means were all in the predicted direction. However, the parametric analyses presented previously indicated that only the first 3 of these distinctions (i.e., those involving heart rate) were statistically significant. The idiographic approach thus enabled determination of how consistently these four autonomic distinctions were shown.

These idiographic analyses revealed that Minangkabau consistently showed the four distinctions among negative emotions. Using data only when both configurations in a distinction met the quality criterion (i.e., ratings of 2 or higher), for the four distinctions among negative emotions, the hit rate for Minangkabau was 63.6% (63 hits in 99 chances), which is significantly greater than chance, $z = 2.71$, $p = .004$.[10] There were only a small number of instances in which *both* configurations in a distinction were of low quality (i.e., ratings of 0 or 1). When this did occur, the hit rate was 37.5% (3 hits in 8 chances), which was below chance levels.

In Table 2 the hit rates for the individual distinctions are presented. Although there was some variation in the hit rates for each of the four distinctions, all exceeded 50%. Among these hit rates, only the largest difference (between 74.2% for the heart rate difference between anger and disgust and 52.2% for the heart rate difference between sadness and disgust) was significant, $z = 1.68$, $p = .046$.

Proportion of subjects showing distinctions. In the foregoing analyses, hits and misses were aggregated across subjects. To

[10] These hit rates were computed using physiological change scores (mean during emotional configuration minus mean during standard control configuration), the same procedure used in our previous studies with Americans. To ensure that the Minangkabau findings were not an artifact of using change scores, we recomputed their hit rates among negative emotions, comparing absolute physiological levels during the emotional configurations. This also produced a significant hit rate of 76.5% (76 hits in 99 chances; $z = 5.33$, $p < .001$).

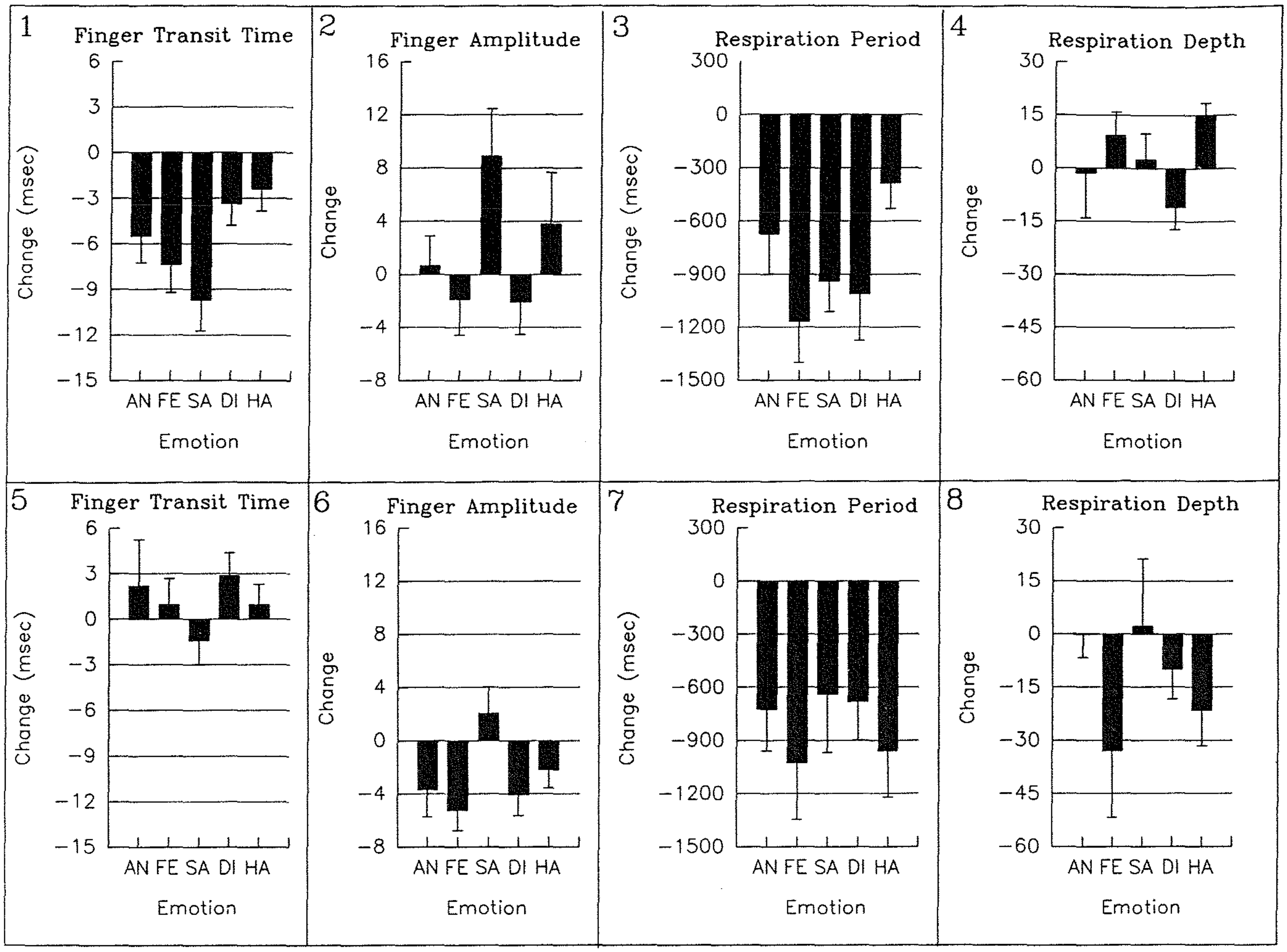

Figure 2. Minangkabau (Panels 1, 2, 3, and 4) and American (Panels 5, 6, 7, and 8) mean change and standard errors for finger pulse transmission time, finger pulse amplitude, respiratory period, and respiratory depth for high-quality configurations in Directed Facial Action task. AN = anger; FE = fear; SA = sadness; DI = disgust; HA = happiness.

determine the extent to which individual subjects showed all or most of the distinctions, we performed a second analysis.

For the distinctions among negative emotions, 7 of the 42 Minangkabau subjects (16.7%) who had usable physiological data for all four negative configurations showed all four patterns, which was significantly greater than chance (6.25%), $z = 2.79$, $p = .003$, and 24 of 42 subjects (57.1%) showed three or four of the patterns, which was also significantly greater than chance (12.5%), $z = 8.75$, $p < .001$.

Effects of reporting emotional experience. Reported emotional experience was associated with greater emotion-specific ANS activity. When Minangkabau reported experiencing any emotion on both of the trials involved in a distinction, the hit rate was 71.4% (35 hits in 49 chances), compared with a 56.0% hit rate (42 hits in 75 chances) when there was no emotion reported. This 15.5% increment associated with experiencing emotion was significant, $z = 1.73$, $p = .041$.

There was not a sufficient number of trials on which Minangkabau reported experiencing *the target emotion* most strongly to permit analysis of hit rates under those more stringent conditions.

Effects of using a mirror. Being able to see one's face in a mirror did not affect the extent of emotion-specific ANS activity. On trials with high-quality configurations, Minangkabau who did not have the mirror had a 65.9% hit rate (27 hits in 41 chances), compared with a 62.1% hit rate (36 hits in 58 chances) for subjects who did have the mirror. This 3.8% decrement associated with the mirror was not significant, $z = 0.39$.

Comparison With American Subjects: Physiological Data

Physiological results predominantly supported cross-cultural consistency for the differences among emotions for Minangkabau and American samples.

Differences in physiological levels during standard control face. Because all analyses of differences among emotions within and between cultures were based on change scores (emotional configuration minus standard control configuration), we

Table 1
Minangkabau and American Physiological Means and Standard Errors for High-Quality Emotional Configurations

Measure	Anger	Fear	Sadness	Disgust	Happiness
Heart rate (beats per minute)					
Minangkabau *M*	3.65	2.46	3.33	−0.09	1.17
Minangkabau *SE*	0.80	1.27	1.08	0.83	0.89
U.S. *M*	4.81	5.29	4.37	0.80	2.27
U.S. *SE*	1.15	1.19	0.96	0.72	0.76
Skin conductance (μmhos)					
Minangkabau *M*	0.21	0.11	0.04	0.05	0.12
Minangkabau *SE*	0.10	0.12	0.09	0.07	0.08
U.S. *M*	0.19	−0.02	0.15	0.03	0.09
U.S. *SE*	0.12	0.09	0.09	0.05	0.04
Finger temperature (°F)					
Minangkabau *M*	0.06	0.10	0.02	0.04	0.05
Minangkabau *SE*	0.07	0.09	0.06	0.08	0.07
U.S. *M*	0.43	0.50	0.42	0.49	0.08
U.S. *SE*	0.16	0.24	0.22	0.12	0.08
Finger pulse transmission time (ms)					
Minangkabau *M*	−5.48	−7.36	−9.71	−3.33	−2.40
Minangkabau *SE*	1.76	1.86	2.04	1.45	1.45
U.S. *M*	2.19	0.96	−1.41	2.89	0.97
U.S. *SE*	3.04	1.73	1.58	1.48	1.32
Finger pulse amplitude (mV)					
Minangkabau *M*	0.64	−1.88	8.89	−2.06	3.80
Minangkabau *SE*	2.25	2.70	3.56	2.47	3.84
U.S. *M*	−3.68	−5.23	2.04	−4.06	−2.18
U.S. *SE*	2.05	1.52	2.01	1.57	1.38
Respiratory intercycle interval (ms)					
Minangkabau *M*	−672.36	−1,168.13	−938.22	−1,011.15	−384.14
Minangkabau *SE*	224.91	233.20	173.52	263.95	145.16
U.S. *M*	−725.86	−1,026.30	−639.58	−681.61	−959.00
U.S. *SE*	233.58	319.69	328.99	217.25	261.86
Respiratory depth (units)					
Minangkabau *M*	−1.39	9.31	2.52	−10.86	15.05
Minangkabau *SE*	12.63	6.67	7.36	6.38	3.42
U.S. *M*	−0.11	−32.89	2.25	−9.94	−21.48
U.S. *SE*	6.52	18.85	19.02	8.38	10.03

conducted an analysis of absolute physiological levels during the standard control configurations. These revealed that Minangkabau had lower skin conductance (Minangkabau = 3.74 μmhos; Americans = 5.78 μmhos), $F(1, 106) = 6.39$, $p = .012$, and shorter pulse transmission times[11] (Minangkabau = 221.4 ms; Americans = 246.43 ms), $F(1, 90) = 37.57$, $p < .001$, than Americans. There were no differences in heart rate, finger temperature, or respiratory period. Cultural comparisons in absolute levels of finger pulse amplitude and respiratory depth would not be meaningful given that the manner in which they were measured did not allow for calibration between subjects.

Differences among emotions in group data. An overall 2 × 5 (Culture × Emotion) MANOVA was computed for the three physiological measures common to all Minangkabau and American subjects (heart rate, skin conductance, and finger temperature). This revealed a significant main effect for emotion, $F(12, 84) = 3.76$, $p < .001$, and a nonsignificant interaction of Culture × Emotion, $F(12, 84) = .98$, indicating that there were differences among emotions and that these differences were consistent across cultures.[12]

A series of 2 × 5 (Culture × Emotion) univariate ANOVAs was

[11] Unfortunately, we did not measure arm and hand length in the Minangkabau subjects and thus do not know whether this finding indicates that Minangkabau subjects had a higher level of sympathetic nervous system activation in this cardiovascular index during the standard control face than Americans or merely had shorter arm length, hand length, or both.

[12] An identically structured MANOVA was computed to determine whether the same findings would obtain if the American comparison group was limited to male subjects. The findings were the same. The main effect for emotion was significant, $F(12, 53) = 4.56$, $p < .001$, and the interaction of Culture × Emotion was nonsignificant, $F(12, 53) = .76$.

Table 2
Hit Rates for Distinctions Between Emotions for Minangkabau and Americans on Trials With High-Quality Facial Configurations

Distinction and culture	No. of hits	No. of chances	Hit rate (%)
Distinctions between negative and positive emotions			
Overall			
Minangkabau	30	49	61.2
American	52	80	65.0
HR acceleration larger for anger than happiness			
Minangkabau	17	28	60.7
American	26	40	65.0
HR acceleration larger for fear than happiness			
Minangkabau	13	21	61.9
American	26	40	65.0
Distinctions among negative emotions			
Overall			
Minangkabau	63	99	63.6
American	90	141	63.8
HR acceleration larger for anger than disgust			
Minangkabau	23	31	74.2
American	22	35	62.9
HR acceleration larger for fear than disgust			
Minangkabau	15	23	65.2
American	23	36	63.9
HR acceleration larger for sadness than disgust			
Minangkabau	12	23	52.2
American	25	40	62.5
TEM increase larger for anger than fear			
Minangkabau	13	22	59.1
American	20	30	66.7

Note. HR = heart rate; TEM = temperature.

computed for trials with high-quality configurations (for these analyses, the same quality criterion rating of 2 or greater was used for both Minangkabau and American subjects). The critical interaction of Culture × Emotion, which would reflect cultural differences in ANS changes during each emotion, was nonsignificant for six of the seven physiological measures:[13] heart rate, $F(4, 289) < 1$; finger temperature, $F(4, 289) < 1$; skin conductance, $F(4, 289) = 1.07$; finger pulse transmission time, $F(4, 233) = 1.03$; finger pulse amplitude $F(4, 233) < 1$; and respiratory period, $F(4, 196) = 2.28$. It was only significant for respiratory depth, $F(4, 167) = 4.25$, $p = .003$.

Differences in overall reactivity. Figure 1 portrays the Minangkabau responses (Panels 1, 2, and 3) and those of the Americans (Panels 4, 5, and 6) for heart rate, finger temperature, and skin conductance, the three measures common to all of our studies to date. Inspection of this figure shows that the magnitudes of some Minangkabau responses appear to be smaller than those of the Americans. This was reflected in a significant culture main effect in the overall MANOVA, $F(3, 93) = 3.92$, $p = .011$. Examination of the culture main effects in the univariate ANOVAs for the seven physiological measures revealed that only skin conductance responses were smaller for Minangkabau (mean change: Minangkabau = .05 μmhos, American = .37 μmhos), $F(1, 105) = 11.37$, $p = .001$. The smaller heart rate responses for Minangkabau approached significance (mean change: Minangkabau = 1.98 beats per minute, American = 3.33 beats per minute), $F(1, 105) = 3.70$, $p = .054$.

Differentiation of sadness. Figure 2 portrays the Minangkabau responses (Panels 1, 2, 3, and 4) and those of the Americans (Panels 5, 6, 7, and 8) for the remaining measures of finger pulse transmission time, finger pulse amplitude, respiratory period, and respiratory depth. It should be noted that differentiation of sadness (greatest shortening of finger pulse transmission time and greatest increase in finger pulse amplitude) can be seen in the data from both cultures. In our previously published work (which did not analyze the finger pulse measures), sadness had been the negative emotion that was the most difficult to differentiate autonomically.

Differences among emotions in idiographic data. As indicated above, the hit rate for distinctions among negative emotions was 63.6% for Minangkabau. Among Americans, the comparable hit rate (using the same configuration quality rating cutoff of 2 or greater) was 63.8% (90 hits in 141 chances). The 0.2% lower hit rate for Minangkabau than for Americans was not significant, $z = -0.03$.[14] Because this finding is quite critical for evaluating our "null" hypothesis of no cultural differences and because sample size has such a large impact on the power of an experiment to detect a difference between groups, we determined how large the sample size would need to be for this difference to be statistically significant. This analysis revealed that it would require almost 700,000 subjects for this difference in hit rates between the two cultures to reach significance at the .05 level.

Because of markedly diminished reactivity in skin conductance among Minangkabau (see below), it was deemed inappropriate to conduct the idiographic analyses for the two distinctions between negative and positive emotions involving skin conductance that have been found previously (Levenson et al., 1990) for young Americans (i.e., greater skin conductance increase for fear than for happiness; greater skin conductance increase for disgust than for happiness). For the other two distinctions (greater heart rate acceleration for anger than for happiness; greater heart rate acceleration for fear than for happiness), the hit rate for Minangkabau was 61.2% (30 hits in 49 chances), whereas the comparable hit rate for Americans was 65.0% (52 hits in 80 chances). The 3.8% lower hit rate for Mi-

[13] Differences in the number of degrees of freedom reflect the number of previous studies with American controls in which the measure was obtained. Heart rate, finger temperature, and skin conductance were obtained in three previous studies, finger pulse transmission time and finger pulse amplitude were obtained in two studies, and respiration period and respiration depth were obtained in one study.

[14] This analysis was repeated to determine whether the same lack of cultural difference would obtain if the American comparison group was limited to male subjects. The findings were the same. Among American men, the comparable hit rate was 64.9% (37 hits in 57 chances). The 1.3% lower hit rate for Minangkabau than for American men was not significant, $z = -0.16$.

nangkabau than for Americans was not significant, $z = 0.43$. Hit rates for the individual distinctions are presented in Table 2.

Differences among emotions in multivariate analysis of patterns. As noted in the preceding section, a null hypothesis that Minangkabau and American cultures do not differ in terms of ANS differences among emotions cannot be proven. What the results of the analyses presented thus far have indicated is that the hypothesis that Minangkabau and American subjects have the same pattern of ANS differences among emotions cannot be rejected. To cast this central question so that a finding of statistical significance would be supportive of the hypothesis of cross-cultural consistency, we conducted a multivariate analysis of ANS patterning.

In this analysis, the data were again change scores (target emotional configuration minus standard control face) for trials with high configuration quality. We first conducted a discriminant function analysis to construct the set of discriminant functions that best characterized the ANS differences among emotions using data only from American subjects. We then conducted a classification analysis in which these "American" discriminant functions were applied to equivalent data obtained from Minangkabau subjects. The percentage of trials in which the American discriminant functions correctly predicted the target emotion for the Minangkabau physiological data was used as an indication of the extent of cross-cultural consistency.

Using the three physiological measures that were common to all studies (heart rate, skin conductance, and finger temperature), we conducted this analysis for the four negative emotions (anger, disgust, fear, and sadness). The American discriminant functions correctly predicted the target emotion for Minangkabau physiological data on 34.6% (45 of 130) of trials, which is significantly greater than chance (25%), $z = 2.53$, $p = .006$. Based on this multivariate pattern analysis, we concluded that there were significant levels of cross-cultural consistency in the autonomic differences among negative emotions.[15]

Comparison With American Subjects: Self-Report and Facial Data

In contrast with the findings of numerous cross-cultural consistencies in physiological findings, self-report and facial data revealed a number of cultural differences between Minangkabau and American subjects.

Configuration quality. A 2 × 5 (Culture × Emotion) ANOVA revealed that the quality of emotional facial configurations produced by Minangkabau was significantly lower than for Americans (mean quality rating: Minangkabau = 2.12, American = 2.69), $F(1, 105) = 23.70$, $p < .001$.

In addition, the emotion main effect was significant, $F(4, 412) = 14.67$, $p < .001$, as was the interaction of Culture × Emotion, $F(4, 412) = 3.16$, $p = .014$. Examination of the interaction using Bonferroni-adjusted t tests revealed that configuration quality was lower for Minangkabau than for Americans for fear, happiness, and sadness, but not for anger or disgust.

Rated difficulty. A 2 × 5 (Culture × Emotion) ANOVA revealed that Minangkabau reported greater difficulty making the facial configurations than had Americans in the one previous study in which these ratings were obtained (mean difficulty rating: Minangkabau = 4.25, American = 2.51), culture, $F(1, 74) = 30.51$, $p < .001$.

In addition, the emotion main effect was significant, $F(4, 288) = 11.81$, $p < .001$, as was the interaction of Culture × Emotion, $F(4, 288) = 2.82$, $p = .025$. Examination of the interaction using Bonferroni-adjusted t tests revealed that rated difficulty was greater for Minangkabau than for Americans for all five configurations.

Report of target emotion: All configurations. Minangkabau were less likely than Americans to report experiencing the emotion that the facial configuration resembled. Minangkabau reported experiencing this target emotion most strongly on 14.7% of trials (33 reports in 225 trials). If we assume that chance is 20.0% (one of five emotions sampled), the Minangkabau report of the target emotion occurred at significantly *less* than chance levels, $z = -2.00$, $p = .02$. In comparison, Americans reported experiencing the target affect most strongly on 33.1% of trials (102 reports in 308 trials), which is significantly greater than chance, $z = 5.76$, $p < .001$. The 18.5% lesser report by Minangkabau was statistically significant, $z = -4.84$, $p < .001$.

Effect of configuration quality on report of target emotion. High configuration quality was associated with greater report of the associated emotion for both Minangkabau and American subjects. When Minangkabau configurations were of high quality (i.e., rated as 2 or higher), they reported experiencing the associated emotion most strongly on 17.5% of trials (29 reports in 166 trials), which was significantly greater than the 6.8% occurrence (4 reports in 59 trials) when configurations were of low quality (i.e., rated as less than 2), $z = 1.99$, $p = .023$. Similarly, when American configurations were of high quality, reports that the associated emotion was experienced most strongly occurred on 35.2% of trials (87 reports in 247 trials), which was significantly greater than the 22.4% occurrence (15 reports in 67 trials) when configurations were of low quality, $z = 1.99$, $p = .023$.

Results from the two cultures for the individual emotions are presented in Table 3.

Effect of mirror on configuration quality. The presence of the mirror had no influence on configuration quality in either culture. A 2 × 2 (Culture × Mirror) ANOVA revealed that the

[15] Because we have not analyzed our data in this way previously and because we have some concerns about the use of discriminant function analysis with within-subject data, we thought it would be useful to provide a point of comparison. Recalling that in previous studies with American subjects we failed to find differences between male and female subjects (Levenson et al., 1990), we conducted a parallel analysis to determine the extent to which discriminant functions based on male American subjects could predict the target emotion for physiological data obtained from female American subjects. The classification analysis revealed that the male discriminant functions correctly predicted the target emotion for female physiological data on 32.7% (33 of 101) of trials, which is significantly greater than chance (25%), $z = 1.78$, $p = .037$. From comparison of the percentage of correct classifications across genders (32.7%) with that obtained across cultures (34.6%), it appears that consistency in the ANS differences among emotions is at least as strong across cultures as it is across genders.

presence or absence of a mirror had no effect on the quality of the emotional configurations for either Minangkabau or American subjects, mirror $F(1, 96) < 1$, Culture × Mirror $F(1, 96) = 1.32$.

Discussion

When young Minangkabau men living in West Sumatra were given muscle-by-muscle instructions to produce facial configurations that resemble emotional expressions, they evidenced patterns of emotion-specific ANS activity that were similar to those found previously in young and old male and female American subjects. These similarities obtained despite marked differences between Minangkabau culture and mainstream American culture in religion (Moslem vs. Judeo-Christian), social organization (matrilineal and extended family vs. patrilineal and nuclear family), economic development (agrarian and developing vs. industrial and developed), beliefs concerning the nature of emotion (interpersonal vs. inner state), social norms regarding emotional expression (strong proscriptions against public expression of negative affect vs. weak proscriptions), and previous experience with scientific experimentation (no experience vs. some experience).

This study provides the first evidence that these relations between voluntary facial actions and patterned ANS activity in emotion are not unique to American culture. Although certainly not establishing universality, these findings clearly disconfirm the alternative hypothesis that every culture is completely different in terms of these aspects of emotion.

Cross-Cultural Consistency: Voluntary Facial Actions and Emotion-Specific Autonomic Activity

Our finding of similarity between Minangkabau and American cultures in the ANS effects of emotional facial actions undermines two rival hypotheses: (a) It is only in American culture that voluntary facial action produces ANS activation; and (b) voluntary facial action produces ANS activation in other cultures, but in every culture a different set of ANS changes is associated with a given voluntary emotional configuration. In addition to these two conclusions, the findings are suggestive in other regards.

Evidence against a learning model. We designed this experiment in part to test an alternative to our hard-wired model. In this alternative model, the capacity of voluntary emotional facial configurations to generate emotion-specific ANS activity derives from a learned association between repeated contiguous pairings of naturally occurring emotional expressions and concomitant physiological activity. By stimulus generalization, voluntary representations of emotional expressions come to be able to trigger the associated physiological activity.

Minangkabau culture, with its strong cultural proscription against the public use of the anger facial expression and its cultural display rule of masking anger displays with neutral or even happy facial expressions, provided a natural laboratory for testing this learning model. To the extent that these proscriptions are effective, Minangkabau would have relatively few learning trials to establish the association between anger facial expressions and associated physiological activity. Thus, this model would predict that voluntary production of anger expressions should be ineffective in eliciting the ANS activity associated with anger for Minangkabau as compared with Americans, who should have no lack of learning trials involving anger expressions.

In contrast with this prediction, our findings for Minangkabau revealed no marked differences between the two cultures in the physiological activation produced by the anger configuration. If the Minangkabau ethnography is correct concerning the relative absence of anger expressions, then these findings would argue against this kind of learning model as the basis for voluntary facial configurations producing emotion-specific ANS activity.[16]

Independence from visual feedback of the face. In our initial work with the Directed Facial Action task (Ekman et al., 1983), we provided subjects with visual feedback of facial behavior in the form of a mirror and being able to see the face of a coach. In subsequent studies we eliminated the coach and repeated the experiment with and without a mirror, but never in a single experiment.

The present study provided an unconfounded test of the necessity of being able to see one's face in a mirror by providing some Minangkabau subjects with a mirror and others with no mirror. The mirror had no impact on the quality of the configurations that were produced, and, more important, had no effect on the extent to which the four key ANS distinctions among negative emotions were found. This supports our conclusion, based on American subjects, that visual feedback of facial expression is not required for the Directed Facial Action task to produce emotion-specific ANS activity.

Cross-Cultural Consistency: Autonomic Differences Among Emotions

Several lines of evidence supported cross-cultural consistency in the ANS changes that accompany different emotions. Group data analyses revealed nonsignificant interactions between culture and emotion for six of seven physiological variables (the interaction was significant only for respiratory depth). Idiographic analyses revealed no cultural differences in the consistency of the two differences between negative and positive emotions on the basis of heart rate that we had found previously in American subjects (Levenson et al., 1990). Idiographic analyses also revealed no cultural differences in the four ANS differences among negative emotions that we had previously found with American subjects to be most robust (i.e., those that had been found to be consistent across variations in

[16] These data are clearly not sufficient to reject completely a learning explanation. Although Minangkabau may produce fewer anger displays than Westerners, this production may still be sufficient to establish learned connections between anger expressions and anger physiology. Furthermore, concealment of *visible* signs of anger by Minangkabau might still allow for activation at the cortical level, the facial nucleus, or the facial muscles. Thus, association of subvisible activation with patterned ANS activity might still occur, providing a basis for voluntary anger configurations activating the associated pattern of ANS activity.

Table 3
Percentage of Trials With Low- or High-Quality Configurations on Which Target Emotion Reported Most Strongly for Minangkabau and American Subjects

	Emotional configuration					
Culture and quality	Anger	Fear	Sadness	Disgust	Happiness	All
Minangkabau						
Low quality	11.1	5.6	6.7	0.0	10.0	6.8
High quality	25.0	17.9	7.4	5.1	30.6	17.5
American						
Low quality	15.8	26.3	14.3	36.4	25.0	22.4
High quality	36.4	29.5	35.4	26.9	45.8	35.2

Note. All values are percentages.

experimental procedure and in subject age, profession, and gender, Levenson et al., 1990). Although the hypothesis of no cultural differences can never be proved, it was noted that the magnitude of found differences between Minangkabau and Americans in these four ANS distinctions among negative emotions was such that it would have required a sample of over 700,000 subjects for it to have reached significance at the .05 level. Finally, a multivariate analysis of ANS differences among negative emotions revealed that discriminant functions derived from American physiological data correctly predicted the target emotion for Minangkabau physiological data at significantly greater-than-chance levels, providing additional support for cross-cultural consistency.

Generality to other modes of elicitation. Although we have only reported the results of the Directed Facial Action task here, we believe these findings are indicative of more generalized cross-cultural consistency in patterns of emotion-specific ANS activity. This assertion is grounded in our belief that patterns of emotion-specific ANS activity produced by the Directed Facial Action task are similar to those produced by other more traditional modes of emotion elicitation.[17] In our own work we have found no differences in the four key distinctions among negative emotions between the Directed Facial Action task and a more traditional task in which subjects relive emotional memories (Levenson et al., 1991). There have also been many findings reported by others using the same and different methods of elicitation that are consistent with these four distinctions (Levenson, 1992).

Differentiation of sadness. In our first study using the Directed Facial Action task (Ekman et al., 1983), we had not been able to distinguish sadness from the other negative emotions using measures of heart rate, finger temperature, and skin conductance. In the Minangkabau data, however, sadness was distinguishable from other negative emotions on the basis of finger pulse transmission time and finger pulse amplitude. After finding this difference in the Minangkabau data, we examined these two measures in two previous American studies (in which they had been obtained but had not been analyzed). The same differences between sadness and the other negative emotions found for the Minangkabau were also found in these American samples, thus increasing our confidence in the generality of this important differentiation.

Cross-Cultural Differences

Report of emotional experience. In prior studies with Americans, compared with physiological findings, the capacity of the Directed Facial Action task to generate subjective emotional experience has proven to be much more vulnerable to differences in subject characteristics (e.g., more prevalent in young subjects than in old subjects, Levenson et al., 1991) and experimental procedures (e.g., more prevalent when visual feedback of the face is *not* present than when feedback is present, Levenson et al., 1990). On the basis of these findings, we hypothesized that the capacity of voluntary facial actions to generate subjective emotional experience is likely to show cultural variation, depending on a variety of attitudinal and cognitive factors that are vulnerable to cultural influence.

For Minangkabau, the Directed Facial Action task was less likely to generate reported experience of the associated emotion than we had found previously with young American subjects. In fact, Minangkabau reported experiencing the target emotion at less-than-chance levels. Assuming that this does not merely reflect an experimental artifact (e.g., problems with the translation of the posttrial inquiry for emotional experience), several possible explanations can be offered. For both Minangkabau and Americans, we found that the Directed Facial Action task was more likely to generate report of the associated emotional experience when configurations were of the highest quality (i.e., when they most closely resembled the associated emotional expressions). Because Minangkabau produced configurations of significantly lower quality than those of Ameri-

[17] This issue of consistency across eliciting tasks has been clearly framed by Stemmler (1989), who compared "real life" and imagery elicitations in a single study. Stemmler, however, reached the conclusion that the nature of ANS activity in emotion depends on the way in which emotions are elicited. While we certainly do not consider the question of generality across elicitors to be settled, several methodological features of Stemmler's work may have contributed to his not finding evidence for generality (e.g., physiology was measured *during* the induction in the imagery condition, but *after* the induction in the "real life" context; the imagery task was presented after another procedure in which the same emotional memory was presented verbally for 5 min, thus increasing the likelihood of habituation).

cans, this could account for their reduced report of subjective emotional experience.

An alternative explanation for the reduction of emotional experience for Minangkabau derives from the nature of emotion in their culture. For Minangkabau, the state produced by the Directed Facial Action task would be much less likely to be labeled as *emotion* because, for them, the task is missing the critical element for emotional experience as defined by their culture, namely, the meaningful involvement of another person. As noted earlier, Heider (1991a, 1991b) has posited that the inner experience of emotion is relatively less important for Minangkabau than are interactionally situated emotional experiences. In contrast, for Americans, the presence of an emotional facial configuration and patterned ANS activation, in the absence of a meaningful encounter with another person, may still be sufficient for labeling the experience as *emotion.*

Can findings be interpreted in terms of emotion? The nature of the Directed Facial Action task begs the question of whether associated findings should be interpreted in terms of emotion or merely in terms of different configurations of facial muscle contractions. As had been the case in our prior work with Americans, a number of findings in the Minangkabau supported interpretation in terms of emotion: (a) report of subjective experience of the emotion associated with facial configurations increased when configurations most closely resembled the associated emotional expressions; (b) ANS distinctions among negative emotional configurations were most prevalent when experience of the target emotion was reported; and (c) ANS differences among facial configurations were most pronounced when configurations most closely resembled the associated emotional expressions. Additional support for this interpretation derives from several other lines of research: (a) Emotional facial configurations, in the absence of other emotional stimuli,[18] have been shown to produce emotional experience (Duclos et al., 1989; Laird, 1974) and emotion-specific physiological activity (McCaul, Holmes, & Solomon, 1982); and (b) the ANS differences among negative emotions produced by the Directed Facial Action task are similar to those produced by more conventional emotion-eliciting tasks such as our Relived Emotions task (Ekman et al., 1983; Levenson et al., 1991) and elicitors used by others, including emotional imagery, attitude induction, natural and staged interaction, and various visual stimuli (see Levenson, 1992, for a review of this evidence).

One strand of evidence was weakened in the present study insofar as Minangkabau were less likely to report emotional experience in the Directed Facial Action task than had Americans. However, the remaining evidence, coupled with our belief that self-report (or any other single feature of emotion) should not be elevated to the stature of "gold standard" for establishing the occurrence of emotion, leads us to conclude that there still is sufficient basis for viewing the Directed Facial Action task as an emotion-eliciting task in the Minangkabau. Even if one disagrees with this conclusion, the finding of cross-cultural consistency in the capacity of voluntary facial action to generate differentiated ANS activity remains.

Low skin conductance reactivity in Minangkabau. One physiological cultural difference that bears comment was the lower skin conductance during the standard control face and the markedly blunted skin conductance reactivity in Minangkabau subjects. We had reason to expect ethnic differences in skin conductance, based on numerous prior reports in domestic samples (e.g., Davis & Cowles, 1989; Johnson & Landon, 1965; Korol, Bergfeld, Goldman, & McLaughlin, 1977) but were aware of no such studies that included Indonesian subjects. The flat skin conductance records[19] we obtained from Minangkabau had the unfortunate consequence of not allowing us to test the generality of differences in skin conductance that had distinguished two negative emotions (fear and disgust) from happiness in our previous studies (Levenson et al., 1990).

A Comment on the Use of Cross-Cultural Methodology

The use of the cross-cultural method is not without problems, especially in terms of possible heterogeneity within cultures and related sampling difficulties. For example, in the present study, we posited a cultural difference in the expression of anger, with Minangkabau less likely to use the anger facial expression and more likely to mask it than Americans. Because it is unlikely that these two cultures have completely nonoverlapping distributions in this regard, the representativeness of our American and Minangkabau samples (as regards this purported cultural difference) became quite critical. Regardless of cultural setting, this kind of sampling issue should not be ignored in any study of group differences. However, in the kind of exotic settings we have chosen for our cross-cultural work, it can be particularly difficult to know whether representative samples have been obtained.

A related problem is the increasing lack of isolation between cultures. Western culture, especially popular music and films,[20] has made definite inroads into Indonesia in recent years. We had no way of knowing precisely how much exposure the young Minangkabau men in our study had had to these aspects of Western culture and to what effect.

These problems notwithstanding, the cross-cultural method provided us with an opportunity to test and extend a number of aspects of our domestic findings. Where we found differences

[18] Other investigators have reported that voluntary facial activity can influence subjective or physiological responses produced by other emotional stimuli. This has been found for voluntarily produced emotional configurations (e.g., Kraut, 1982; Strack, Martin, & Stepper, 1988) and for instructed alterations (e.g., inhibiting or exaggerating) of naturally occurring facial expressions (e.g., Colby, Lanzetta, & Kleck, 1977; Gross & Levenson, 1991; Lanzetta, Cartwright-Smith, & Kleck, 1976; Leventhal & Mace, 1970). Failures to find these influences have also been reported (e.g., Tourangeau & Ellsworth, 1979).

[19] We carefully checked our equipment in Bukittinggi to make sure that the low skin conductance readings did not result from malfunction or from the unusual climactic conditions. Electronic tests revealed that the equipment was working properly, and we were able to confirm that our own levels of electrodermal reactivity under those climactic conditions were not altered.

[20] Similar to their American counterparts, Indonesian films often include anger behavior that is much more intense than normally occurs in "real life" (Heider, 1991a). These visual materials increase the opportunities for Indonesians to learn the kinds of emotional associations that would not normally be provided in their culture.

between the Minangkabau and American cultures (e.g., aspects of reported subjective emotional experience), we could clearly reject a hypothesis of universality. Where we found similarities between the two cultures (e.g., aspects of the relations between voluntary facial action and emotion-specific ANS activity), we could clearly reject the notion that every culture is unique in these regards. Of course, finding replicability in two cultures is only a first step toward establishing universality, but if cultures are highly disparate in ways directly related to the aspects of emotion being studied, as was the case here, then we consider the size of that step to be significant.

Methods for Studying the Physiological Characteristics of Emotion in Cross-Cultural Studies

We gave a great deal of thought to how best to study emotion in the Minangkabau. Emotion-eliciting tasks with arguably high ecological validity can be highly vulnerable to cultural distortions. An instruction to an American to relive an emotional memory of sadness, for example, will only mean the same thing for a Minangkabau if one uses a Minangkabau word that has precisely the same meaning as *sadness.* Films with spoken soundtracks present similar problems of translation. Finding translation equivalents is always difficult and sometimes impossible, depending on the ways in which emotion words map onto each other in the languages involved.[21] Additionally, the emotional meaning of a film can be altered markedly when viewed through different cultural filters. A silent film of a puppy playing with a flower, which we have found to reliably elicit amusement in American college students, could produce a quite different and complex emotional response in young Minangkabau men, whose Moslem religion views dogs as unclean, but whose culture condones both the keeping of dogs for security and their use for hunting wild pigs in the jungle (an important act of masculinity; Errington, 1984).

The Directed Facial Action task, which could be argued to have relatively low ecological validity, has a number of marked advantages when used in different cultures. It requires no difficult translation of emotion language. One need only translate instructions such as *raise, lower,* and *tighten* and translate parts of the face such as *eyebrow, cheek,* and *lip.* The accuracy of the translation can readily be evaluated in terms of whether subjects produce the desired facial muscle actions. Verification of emotion elicitation, which may depend heavily on just those kinds of self-report data that are most vulnerable to cultural influence, and temporal matching between elicitation and physiological response, which is a thorny problem for all kinds of emotion elicitation (Levenson, 1988), are greatly simplified in the Directed Facial Action task. It is relatively straightforward to verify that all of the requested muscle actions were made and that no extraneous muscle contractions from other emotions were present. The precise time interval during which the entire emotional configuration was present can be readily determined and physiological activity can be extracted in temporal proximity to that interval.

Conclusions

We have found cultural similarities between Americans and Minangkabau in the capacity of voluntarily produced emotional facial configurations to produce ANS activation and in the emotion-specific patterns of that ANS activity. On this basis, we can reject alternative hypotheses that these findings are unique to American culture or that every culture learns a completely different set of relations between these aspects of expression and physiology in emotion.

We have found cultural differences between Americans and Minangkabau in the reported experience of emotion produced by voluntarily constructing emotional facial configurations. To the extent that this finding is not merely a result of the lower configuration quality produced by Minangkabau, a hypothesis of universality for this feature of emotion can be rejected. Self-report of emotion is likely to be vulnerable to influence by culturally variable factors, with cultural learning playing a major role in influencing which states will be labeled as being *emotion,* and, if so labeled, which emotion term will be used.

Although we have hypothesized that the relations between voluntary facial action and patterned ANS activity in emotion are hard-wired and universal, we cannot rule out the possibility that Minangkabau and American cultures learned the same relations and that other unstudied cultures might have learned different relations. We do believe that these two cultures, which are different in so many ways (including religion, social organization, economic development, beliefs concerning the nature of emotion, social norms regarding emotional expression, and previous experience with scientific experimentation), provided an unusually severe test for the hypothesis of cross-cultural consistency. If cultural differences had emerged, the universality hypothesis could have been rejected. Findings of cultural differences would also have dealt a severe blow to the hard-wired hypothesis, which would either have to be rejected outright or modified to include the possibility of the prepotency of culture-specific learning over some preexisting hard-wiring.

Although clearly not definitive in these regards, our failure to find cultural differences strengthens our belief that patterns of emotion-specific ANS activity and the capacity of voluntary facial action to generate this patterned activity will ultimately prove to be both universal and based on hard-wiring, representing an important part of our common evolved biological heritage.

---

[21] Heider (1991b) has shown the complexity of this translation problem. Comparing the closest translation equivalents for six emotions between English and Minangkabau, it appears that for four emotion terms (sadness, anger, happiness, and surprise) there are very close equivalents in Minangkabau. However, for fear it is somewhat difficult, and for disgust it is extremely difficult to find a close equivalent in Minangkabau.

References

Abdullah, T. (1966). Adata and Islam: An examination of conflict in Minangkabau. *Indonesia, 2,* 1–24.

Averill, J. R. (1980). A constructivist view of emotion. In R. Plutchik & H. Kellerman (Eds.), *Emotion: Theory, research, and experience. Vol. 1: Theories of emotion.* (pp. 305–339). San Diego, CA: Academic Press.

Boucher, J. D. (1983). Antecedents to emotions across cultures. In S. H. Irvine & J. W. Berry (Eds.), *Human assessment and cultural factors* (pp. 407–420). New York: Plenum Press.

Boucher, J. D., & Brandt, M. E. (1981). Judgment of emotion. American and Malay antecedents. *Journal of Cross-Cultural Psychology, 12,* 272–283.

Brown, D. E. (1982). Psychological stress and culture change in a group of Filipino-Americans: A preliminary study. *Annals of Human Biology, 9,* 553–563.

Clarke, N. P., Smith, O. A., & Shearn, D. W. (1968). Topographical representation of vascular smooth muscle of limbs in primate motor cortex. *American Journal of Physiology, 214,* 122–129.

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

Davis, C., & Cowles, M. (1989). Some sources of variance in skin conductance. *Canadian Journal of Psychology, 43,* 97–103.

Delgado, J. M. (1960). Circulatory effects of cortical stimulation. *Physiological Reviews, 40,* 146–178.

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.

Edelmann, R. J., & Iwawaki, S. (1987). Self-reported expression and consequences of embarrassment in the United Kingdom and Japan. *Psychologia: An International Journal of Psychology in the Orient, 30,* 205–216.

Ekman, P. (1972). Universals and cultural differences in facial expressions of emotion. In J. Cole (Ed.), *Nebraska symposium on motivation, 1971* (pp. 207–283). Lincoln: University of Nebraska Press.

Ekman, P. (1984). Expression and the nature of emotion. In K. S. Scherer & P. Ekman (Eds.), *Approaches to emotion* (pp. 319–343). Hillsdale, NJ: Erlbaum.

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

Ekman, P. (in press). An argument for basic emotions. *Cognition and Emotion.*

Ekman, P., & Friesen, W. V. (1969). The repertoire of nonverbal behavior: Categories, origins, usage, and coding. *Semiotica, 1,* 49–98.

Ekman, P., & Friesen, W. V. (1971). Constants across cultures in the face and emotion. *Journal of Personality and Social Psychology, 17,* 124–129.

Ekman, P., & Friesen, W. V. (1975). *Unmasking the face: A guide to recognizing emotions from facial clues.* Englewood Cliffs, NJ: Prentice-Hall.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system.* Palo Alto, CA: Consulting Psychologists Press.

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

Ekman, P., Sorenson, E. R., & Friesen, W. (1969). Pan-cultural elements in facial displays of emotion. *Science, 164,* 86–88.

Eliasson, S., Lindgren, P., & Uvnas, B. (1952). Representation in the hypothalamus and the motor cortex in the dog of the sympathetic vasodilator outflow to the skeletal muscles. *Acta Physiologica Scandinavica, 27,* 18–37.

Errington, F. K. (1984). *Manners and meaning in West Sumatra. The social context of consciousness.* New Haven, CT: Yale University Press.

Fulton, J. F. (1949). Cerebral cortex: Autonomic representation in precentral motor cortex. In J. F. Fulton (Ed.), *Physiology of the nervous system* (pp. 468–484). New York: Oxford University Press.

Green, H. D., & Hoff, E. C. (1937). Effects of faradic stimulation of the cerebral cortex on limb and renal volumes in the cat and monkey. *American Journal of Physiology, 118,* 641–658.

Gross, J. J., & Levenson, R. W. (1991). *Emotional suppression: Physiology, self report, and expressive behavior.* Manuscript submitted for publication.

Heider, K. G. (1984, November). *Emotion: Inner state versus interaction.* Paper presented at the meeting of the American Anthropological Association, Denver, Colorado.

Heider, K. G. (1991a). *Indonesian culture and cinema.* Honolulu: University of Hawaii Press.

Heider, K. G. (1991b). *Landscapes of emotion. Three cultures of emotion in Indonesia.* Cambridge, England: Cambridge University Press.

Hsu, S. H., Hwang, K., & Chu, H. N. (1942). A study of the cardiovascular changes induced by stimulation of the motor cortex in dogs. *American Journal of Physiology, 137,* 468–472.

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

Johnson, L. C., & Landon, M. M. (1965). Eccrine sweat gland activity and racial differences in resting skin conductance. *Psychophysiology, 1,* 322–329.

Kato, T. (1982). *Matriliny and migration. Evolving Minangkabau traditions in Indonesia.* Ithaca, NY: Cornell University Press.

Kennard, M. A. (1937). The cortical influence on the autonomic nervous system. *Bumke und Foersters Handbuch für Neurologie, 2,* 476–491.

Keppel, G. (1982). *Design and analysis: A researcher's handbook.* Englewood Cliffs, NJ: Prentice-Hall.

Korol, B., Bergfeld, G. R., Goldman, H., & McLaughlin, L. J. (1977). Use of the pigmentometer, a new device for measuring skin albedo: Relating skin color with a series of physiological measures. *Pavlovian Journal of Biological Science, 12,* 19–31.

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

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.

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.

Lazarus, R. S., Opton, E., Tomita, M., & Kodama, M. (1966). A cross-cultural study of stress-reaction patterns in Japan. *Journal of Personality and Social Psychology, 4,* 622–633.

Levenson, R. W. (1988). Emotion and the autonomic nervous system: A prospectus for research on autonomic specificity. In H. Wagner (Ed.), *Social psychophysiology and emotion: Theory and clinical applications* (pp. 17–42). London: Wiley.

Levenson, R. W. (1992). Autonomic nervous system differences among emotions. *Psychological Science, 3,* 23–27.

Levenson, R. W., Carstensen, L. L., Friesen, W. V., & Ekman, P. (1991). Emotion, physiology, and expression in old age. *Psychology and Aging, 6,* 28–35.

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

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

Lutz, C. A. (1982). The domain of emotion words in Ifaluk. *American Ethnologist, 9,* 113–128.

Lutz, C. A. (1988). *Unnatural emotions: Everyday sentiments on a Micronesian atoll and their challenge to Western theory.* Chicago, IL: University of Chicago Press.

Magnusson, D., Stattin, H., & Saburo, I. (1983). Cross-cultural comparisons of situation anxiety reactions. *Series in Clinical and Community Psychology: Stress and Anxiety, 2,* 177–190.

McCaul, K. D., Holmes, D. S., & Solomon, S. (1982). Voluntary expressive changes and emotion. *Journal of Personality and Social Psychology, 42,* 145–152.

Scherer, K. R., Wallbott, H. G., & Summerfield, A. B. (1983). Cross-national research on antecedents and components of emotion: A progress report. *Social Science Information, 22,* 355–385.

Spiegal, E. A., & Hunsicker, W. C. (1936). The conduction of cortical impulses to the autonomic system. *Journal of Nervous and Mental Disease, 83,* 252–274.

Stemmler, G. (1989). The autonomic differentiation of emotions revisited: Convergent and discriminant validation. *Psychophysiology, 26,* 617–632.

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

Thompson, F. J., Lerner, D. N., Fields, K., & Blackwelder, A. (1980). Projection of limb venous afferents to the feline motor-sensory cortex. *Journal of the Autonomic Nervous System, 2,* 39–45.

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.

Tsunoda, T. (1979). Difference in the mechanism of emotion in Japanese and Westerner. *Psychotherapy and Psychosomatics, 31,* 1–4.

Wall, P. D., & Pribram, K. H. (1950). Trigeminal neurotomy and blood pressure responses from stimulation of lateral cerebral cortex of Macaca Mulatta. *Journal of Neurophysiology, 13,* 409–412.

Received September 27, 1990
Revision received January 9, 1992
Accepted January 28, 1992 ■