JOURNAL OF EXPERIMENTAL SOCIAL PSYCHOLOGY **20**, 195–216 (1984)

Facial and Autonomic Manifestations of the Dimensional Structure of Emotion

WARD M. WINTON, LOIS E. PUTNAM, AND ROBERT M. KRAUSS

Columbia University

Received February 10, 1981

While subjects viewed and rated a series of 25 emotionally evocative slides, their heart rate and skin conductance were continuously monitored and their facial expressions were covertly videotaped. Judges subsequently viewed the videotapes and rated trial-by-trial the pleasantness and intensity of each subject's facial expressions. Both phasic skin conductance responding and judged facial intensity were curvilinearly related to self-reported pleasantness, with the largest responses occurring at both extremes of the self-report scale. In contrast, phasic cardiac reactions and judged facial pleasantness were linearly related to self-reported pleasantness; extreme pleasantness was accompanied by heart rate acceleration, and unpleasantness by cardiac deceleration. The results suggest that visceral information reflects the dimensions that underlie the organization of affects and, hence, may play a more important role in emotional experience than is assumed in a number of currently held theories of emotion.

Although psychologists currently seem most impressed by man's intellectual capacities, probably no facet of human experience is more fascinating to the layman than the emotions. One speaks of "being in the grip" of a strong emotion and that seems a particularly apt figure of speech. The experiences of rage, or euphoria, or fear are qualitatively different from other states. One experiences a loss of control, a sense of functioning on a more primitive and less reflective level. Psychological research on the emotions has been concerned primarily (but not exclusively) with two enduring questions: (1) What is the source of our emotional

Ward Winton is now at the Department of Business Administration, Georgetown University. This research was supported in part by Bell Laboratories, Murray Hill, NJ. We are grateful to Julian Hochberg and William J. McGuire for their comments on an earlier draft of this manuscript. We also thank Bruno Anthony for his assistance with the heart rate analyses, and Eric Dubow, who helped code and keypunch the data. Portions of this research were presented at the 87th Annual Convention of the American Psychological Association in September 1979. Requests for reprints should be sent to R. M. Krauss, Department of Psychology, Columbia University, 400 Schermerhorn Hall, New York, NY 10027.

0022-1031/84 $3.00

experience? (I.e., what are the physiological and cognitive factors that determine the feelings we experience?) (2) How well can we know the emotions of others? (I.e., to what extent are an individual's internal feelings accessible to others?)

As every student learns in introductory psychology, the initial coherent theoretical response to the first question was formulated by William James (1884, 1890/1950). Arguing against the common-sense view that the visceral changes associated with particular emotions are the product of an internal, experiential state, James's explanation, which has come to be known as the James–Lange theory, reversed the causal sequence. "Bodily changes follow directly the perception of the exciting fact and . . . our feeling of the same changes as they occur IS the emotion" (James, 1884, pp. 189–190). That is to say, what we experience is simply our apprehension of the bodily changes caused by some affect-inducing stimulus or circumstance.

James's counterintuitive proposition was challenged by many of his contemporaries, notable among them the physiologist Walter Cannon, who argued against the James–Lange theory on several grounds. Perhaps the most critical objection he raised was that the same visceral changes occur in a number of quite different emotions, and in certain nonemotional states as well. If different emotions are accompanied by the same internal changes, Cannon (1927) argued, how could emotional experience consist simply of our perception of such changes?

The assumption that emotional arousal (i.e., the visceral changes that accompany emotional experience) is general and undifferentiated forms the cornerstone of what appears to be the dominant contemporary social psychological theory of the emotions, that of Schachter and Singer (1962). Their theory posits a process with two components: emotional arousal and the arousing situation or context. According to Schachter and Singer, the situation induces an internal state of arousal that is undifferentiated. This in turn impels the individual to identify the source of the arousal. It is the conjunction of an aroused internal state and a stimulus to which that arousal is attributed that, for Schachter and Singer, forms the core of emotional experience.

The Schachter–Singer model has served as the prototype for a large class of theories in social psychology. For example, parallel formulations have been advanced to explain such diverse phenomena as the effects of crowding (Worchel & Teddlie, 1976; Worchel & Yohai, 1979), the nonverbal communication of intimacy (Patterson, 1976; Schaeffer & Patterson, 1980), altruistic behavior (Gaertner & Dovidio, 1977), and cognitive dissonance (Cooper, Fazio & Rhodewalt, 1978; Zanna & Cooper, 1974). Common to all these formulations is the assumption of an internal state of arousal that is general and undifferentiated, and therefore uninformative.

The assumption of generalized arousal is also central to the theory of emotion recently put forward by Marshall and Zimbardo (1979) and Maslach (1979). According to these authors, generalized activation is usually interpreted negatively. Their views are at odds with those of Schachter and Singer, but the assumption of undifferentiated arousal plays a crucial role in both formulations.

A very different view of arousal is that it is multidimensional and nonunitary. The theory of dissociation of response systems, espoused chiefly by the Laceys (Lacey, 1959, 1967; Lacey & Lacey, 1958, 1970, 1974), holds that arousing stimuli may cause different physiological response systems to change in different directions. According to the Laceys, cardiac and electrodermal responses are not only uncorrelated—they may even change systematically in opposite directions under certain circumstances. This alternative view of arousal underpins the present study.

While understanding the origins of emotional *experience* has been a matter of longstanding concern for psychologists, an equally venerable tradition has focused on another aspect of the phenomenon, namely the origins of emotional *expression*, and particularly the facial expression of emotion. Charles Darwin (1872/1955) was not the first investigator to study the expression of emotion, but he is the historic figure most closely associated with the topic. One of the central questions addressed by Darwin concerned the universality of facial expressions of emotion, that is, the extent to which they are independent of culture and learning. This interest led Darwin to study empirically the accuracy with which facial expressions of emotion could be identified, a question that came to dominate research on facial expression in the ensuing years.

One by-product of such research has been the discovery that the domain of emotional expression can be characterized by a relatively simple underlying structure. Schlosberg demonstrated that facial expressions of emotion could be reasonably well differentiated in a two- or perhaps three-dimensional scheme (Schlosberg, 1941, 1952, 1954). More recent research has improved considerably on the methodology for reaching this conclusion, but the conclusion itself has not changed very much. Using a wide variety of stimulus materials and a diversity of scaling techniques, two dimensions seem consistently to emerge. One dimension reflects what might be termed the evaluative aspect of the emotion: how pleasant or unpleasant it is; the other reflects the expression's intensity or activation. While several investigators have reported additional dimensions, generally speaking they tend to account for small amounts of variance, are not orthogonal to the other dimensions, are not found consistently from study to study, and/or do not have a straightforward psychological interpretation. This is not to say that the two dimensions are adequate to make very subtle distinctions between similar emotions (as, for example, between contempt and disgust). But for what have been called the primary emotions, the two-dimensional solution does a reasonably good and parsimonious job.

Over the course of the past two decades, there has been a convergence between the study of the origins of emotional experience and the study of facial expression of emotion. One question this convergence has raised concerns the relation betwen emotional expressiveness and visceral responsivity. In recent years, two quite different positions have emerged. One, which might be termed the "discharge model," derives in a rough way from psychoanalytic thinking. It posits a hydraulic or reciprocal realtionship between the two: internal and external reactivity will be negatively correlated (e.g., Jones, 1950). The opposing theoretical position, which can be termed the "facial feedback" model (Gellhorn, 1964; Izard, 1971, 1977; Tomkins, 1962), makes the opposite prediction. The facial feedback model, which is really a special case of the James–Lange theory, holds that emotional experience is a result of feedback from the facial musculature and, hence, predicts that expressiveness and internal reactivity will be positively correlated. The literature provides evidence for and against both positions. While it is beyond the scope of this paper to review all of the relevant literature, it is useful to consider two widely-cited sets of studies—one set by Buck and colleagues, the other by Lanzetta, Kleck and their associates.

In support of the discharge model, Buck and his colleagues found that an individual's facial expressiveness to emotionally evocative slides was inversely related to concurrent electrodermal responding (Buck, 1977; Buck, Miller, & Caul, 1974; Buck, Savin, Miller, & Caul, 1972). In contrast, Lanzetta, Cartwright-Smith, and Kleck (1976) found intensity of expressiveness to be positively related to magnitude of skin conductance responses, and a related result was reported by Kleck, Vaughan, Cartwright-Smith, Vaughan, Colby, and Lanzetta (1976). They interpreted their findings as support for the facial feedback model.

The apparent disparities between these two sets of findings are not entirely surprising, considering the different methods that different investigators have employed. The most noteworthy differences involve the measures of facial and physiological responding and the types of evocative stimuli used. In Buck's studies the measure of "facial expressiveness" found to be negatively correlated with electrodermal responding was a measure of communication accuracy, i.e., the correlation between a subject's own pleasantness ratings and those of a judge observing the subject's spontaneous facial expressions during stimulus presentation. In the Lanzetta et al. (1976) and the Kleck et al. (1976) studies, on the other hand, facial expressiveness in anticipation of, or evoked by, electric shock was manipulated either by instructions (e.g., to conceal or to reveal), or by the presumably inhibiting presence of an observer. Electrodermal responding was attenuated both under conceal instructions and when an observer was present.

Both the self-ratings and the expressiveness ratings in Lanzetta et al. (1976) and Kleck et al. (1976) were measures of shock painfulness; thus, they tapped the intensive dimension of affective response. In the Buck studies, however, the slide stimuli presumably evoked affective responses varying along both evaluative and intensive dimensions, while subjects' and judges' ratings of affect specifically concerned the evaluative dimension.

If intensive and evaluative aspects of affective experiences are independent dimensions, one would expect them to show different relationships to a particular physiological response. Furthermore, different physiological response systems might reflect different dimensions of affective experience. In another domain, Graham and Jackson (1970) and Jackson (1974) have postulated that electrodermal and cardiac responses to simple tonal stimuli index intensive and directional (i.e., attentional) aspects of arousal, respectively. Electrodermal responding increases monotonically with stimulus intensity. The decelerative cardiac response, on the other hand, is directly related to the attention-evoking characteristics of stimuli. Thus, stimulus intensity and cardiac deceleration are nonmonotonically related to one another; they increase together from perceptual threshold to moderate intensity levels, but as intensity is increased to noxious levels, cardiac deceleration declines and is replaced by acceleration (a defensive response).

While the intensive dimension in the Graham and Jackson scheme is one of the primary dimensions of affective response discussed above, the attention–interest dimension is not.[1] How is the attention–interest dimension related to the evaluative dimension, and how is the latter reflected in physiological responding? An important study by Libby, Lacey, and Lacey (1973) has shown that cardiac responses evoked by affective slides are systematically related to both dimensions, but in opposite ways. That is, cardiac responses become increasingly decelerative both with increases in attention–interest (as in orienting) and with decreases in stimulus pleasantness.

These studies suggest the possibility that phasic electrodermal and cardiac responses may reflect the same dimensions that underlie affective facial expressions, namely, intensity and evaluation. Specifically, we would expect the evaluative dimension to be reflected in cardiac responses and the intensive dimensions to be reflected in electrodermal activity. No study of concurrent facial and physiological responding during induced affect has directly investigated this possibility by monitoring phasic activity in both electrodermal and cardiovascular response systems. The phasic

[1] Schlosberg (1952, 1954) named one emotion dimension "attention–rejection," but such a dimension has not emerged in more recent studies employing more powerful scaling techniques.

responses discussed by Libby et al. (1973), by Graham and Jackson (1970), and by Jackson (1974) are relatively rapid, short-lived changes that peak within a few seconds of stimulus presentation. The bodily changes of primary interest to activation theories (e.g., Malmo, 1959), on the other hand, are tonic changes that take place over minutes. While Notarius and Levenson (1979) did record heart rate, skin conductance, and facial expression during affect, theirs were measures of tonic changes in which the minimum temporal unit examined was 1 min.

Buck and colleagues also recorded heart rate, along with electrodermal and facial responses, and reported no significant heart rate response to affective slide presentation (Buck et al., 1972, 1974). Their failure to find such a response is probably attributable to their method of averaging heart rate over a 10-beat or a 10-sec period, thereby obscuring the phasic response of interest. This is particularly likely since the 10 sec between slide onset and signaled verbal report probably contained a polyphasic heart rate (HR) response, e.g., acceleration followed by deceleration.

The present study was designed to examine facial and physiological responding associated with both the intensive and evaluative dimensions of affective experience. Subjects viewed a series of 25 emotionally evocative slides in a paradigm similar to that of Buck and colleagues (Buck et al., 1972, 1974). Heart rate and skin conductance responses were recorded, as were self-reports of slide pleasantness. Facial expressions were covertly videotaped and were later shown to judges who rated both the pleasantness and intensity of the subjects' affective response.

As detailed below, the major deviation from the procedure used by Buck and colleagues concerned the quantification of the physiological responses. Most importantly, second-by-second changes in cardiac response to stimulus slides were examined, along with phasic electrodermal responses, in order to determine if cardiac activity, like judges' pleasantness ratings, would reflect the evaluative dimension, and if electrodermal responses would reflect the intensive dimension. Such a demonstration of dissociation of physiological response systems, or directional fractionation (e.g., Lacey & Lacey, 1958), would add to our understanding of the relationship between subjective emotional experience and its bodily expression, providing data relevant both to theories of emotion based on a construct of unidimensional, undifferentiated arousal and to contemporary versions of the James–Lange position.

METHOD

Participants

Twenty-four male Columbia undergraduates viewed the slides and were paid $4 for their participation. Data were not analyzed for four subjects. Two guessed that a hidden camera was present and two objected to the videotaping procedure after it was revealed to them.

Ninety undergraduates judged the subjects' facial expressiveness by viewing the videotapes.

These included 30 men and 30 women who judged edited segments that were each 30 sec long, and 30 additional men who judged edited segments that were each 10 sec in length. Eighteen judges received course credit for their participation, and seventy-two were paid $3 each.

An additional 20 men and 20 women had previously received $2.50 each for participating in an initial slide selection procedure.

Slide Selection

Ten color pictures in each of five categories were culled from various books and magazines. These categories were the same as those used by Buck and colleagues (1972, 1974)[2]: *Sexual* photographs of women taken from *Playboy* magazine; *Scenic* depictions of landscapes, trees, and beaches; *Pleasant* pictures of adults and children at leisure; *Unpleasant* photographs from a medical text, showing people badly burned or mutilated; and *Unusual* pictures including cubist paintings and time-lapse photos. Slides made from these pictures were shown to judges who were asked to indicate which of the five categories was most appropriate for each slide. A total of 40 judges participated, in groups of 2 to 5 at a time. The five slides eliciting the highest interjudge agreement in each category were chosen as stimuli for the slide-viewing experiment. For each of the 25 slides selected, a minimum of 73 percent of the judges agreed on its categorization.

Procedure

The subject was seated in a comfortable armchair in a moderately lit, air-conditioned, 3 × 2.5m room. He sat approximately 1.5m from a 38 × 38cm rear-projection screen on which the slides were projected from an adjacent control room. Several elaborate-looking pieces of equipment rested on a table next to the screen. Among these were a white noise generator and a sham "distortion monitor" (Olson, 1978), which concealed a Panasonic WV-240p video camera. The video cable was entwined with several purposeless wires that led into the next room. The presence of this apparatus was explained to the subject by telling him that "in some sessions, we play white noise through this speaker, and then we have to use all this equipment here. But in today's session, you'll be listening to white noise through earphones, so we won't be using any of this."

The subject was told that the experiment was on "physiological and vocal responses" to pictures of various kinds. He was instructed to describe verbally how each slide made him feel, first by rating its pleasantness on a 7-point Likert-type scale (depicted near the screen) and then by talking freely. He was told to refrain from speaking immediately after slide onset, and to wait for a signal light next to the screen before talking. This procedure was similar to that of Buck et al. (1972, 1974) and it ensured that the physiological records during the first 20 sec after slide onset would be uncontaminated by the effects of vocalization. In the Buck studies, however, subjects rated the slides *after* speaking freely about their feelings, not before. After explaining the slide-viewing procedure, the experimenter asked the subject to sign a form indicating that he understood his remarks would be recorded on audio tape. All subjects agreed to sign.

The experimenter then asked the subject to put on a pair of Sennheiser HD414 headphones. These headphones delivered 82 db of continuous white noise, filtered to restrict its range to 150–600 Hz[3], in order to mask sounds accompanying slide projector operation. The

---

[2] We originally planned to use copies of the stimulus slides used in the Buck et al. studies. Buck was kind enough to have a duplicate set made for us, but the colors were so distorted as to render them unusable.

[3] An unfiltered signal of 81 dB is fairly intense, but the high-frequency filtering process produced a signal that was not aversive and sounded rather like a waterfall.

experimenter then affixed electrodes (Beckman regular Ag–AgCl) to measure skin conductance and heart rate. For skin conductance, electrodes were attached to the distal phalanges of the index and middle fingers of the left hand, with K-Y Jelly serving as the electrolyte. For heart rate, electrodes were attached in a standard lead II configuration.

Subjects were then instructed to relax and sit quietly for 10 min. After this adaptation period, the experimenter reentered the room and told the subject he would now view five "practice" slides to clear up any questions he might have regarding the procedure. These slides were drawn from the original group of 50 slides described above. Practice slides had not elicited high interrater agreement, but were most often assigned to the Scenic, Pleasant, or Unusual categories. After administering the practice slides, the experimenter returned to the subject room to ensure that the subject fully understood his task. The experimenter then initiated the sequence of 25 stimulus slides, remaining in the control room for the duration of the slide-viewing period.

Each stimulus slide was projected for 30 sec, and the rating-response signal in the subject's room was illuminated during the last 20 sec. Between stimulus slides, a blank slide was projected for 8 sec. Order of presentation of the 25 slides was determined by a Latin square design, such that each slide category occurred once per five-trial block. Two 5×5 Latin squares were used; half of the subjects viewed the order of slide presentation determined by one square, and half by the other.

After the final slide, the experimenter returned to the subject's room, removed the electrodes and earphones, and debriefed the subject. The covert videotaping procedure was explained, and the subject was asked to sign a consent form permitting the videotapes to be used in the subsequent parts of the experiment. Two subjects declined to sign, and their tapes were erased.

Apparatus

Skin conductance was recorded on a Beckman 411 polygraph using a constant-voltage coupler, and EKG was recorded on a second polygraph channel as well as on a Sony TC-630 audio trape recorder for off-line analyses. The tape-recorded EKG and slide-onset signals were later played into a Hewlett–Packard 521 AR electronic counter and 561-B digital recorder which timed and printed R–R interval durations to the nearest msec.

An 8-cam timer and two model 131C Hunter timers controlled timing of stimulus onsets as well as event signals on the polygraph and audio tape recorder. White noise background was produced by a General Radio 1390-B Random Noise Generator, filtered by an Allison Laboratories Model 2BR Band Pass Filter, and calibrated using the C-scale of a General Radio 155C sound level meter equipped with flat plate adaptor. Audio and video recordings of the subject were made on a Sony V0-2800 videocassette recorder.

Expressiveness Judgments

The videotapes of the subjects were viewed by 30 male and 30 female judges, who rated the pleasantness and intensity of the subjects' emotional reactions on 7-point Likert-type scales. Specifically, judges were instructd to "indicate on the appropriate scale how pleasant or unpleasant you think the viewer's emotional reaction was, and how intense it was." These ratings will be subsequently referred to as facial pleasantness and facial intensity. Each judge viewed all 25 trials, in consecutive order, for each of two subjects. Each subject was viewed by a total of six judges, and raters participated in groups of one to five. These judgments were made by viewing the subjects' facial reactions during the full 30 sec of slide presentation.

An additional 30 judges made their ratings by watching edited videotapes which showed only the facial expressions that occurred during the first 10 sec of slide presentation. Since no sex differences in decoding ability were found among the first group of judges, only males were involved in this 10-sec judgment task. In these 10-sec ratings, each judge viewed two subjects, and each subject was viewed by three judges.

The videotapes were edited so that judges could hear the sound of the slide projector changing, and they were instructed to watch the subject's face carefully to observe his first reactions. Judges could not hear subjects describing their reactions, but they were told that this was the subjects' task. Judges also were apprised of the five different slide categories.

It should be noted that the above procedures differed from those of Buck and colleagues (1972, 1974, 1977), whose analyses of expressiveness involved one judge per subject and one subject per judge. By increasing the number of judges per subject and subjects per judge, the present study attempted to unconfound sender and receiver characteristics.

Response Measures

Skin conductance. Skin conductance responses (SCRs) were manually scored from polygraph records, using a minimum response criterion of .1μmho. Scoring was carried out without knowledge of which slide categories were presented on each trial. A frequency distribution of SCR peak latencies showed three periods of activity in the 13 sec following slide onset. An initial response peaked within 1 to 5 sec, presumably reflecting initial impact of the slide. A second response period, 5 to 11 sec after onset, perhaps reflected anticipation of the rating-response signal. A third period, accompanying subjects' verbal responses, began at 12 sec. A latency distribution of this kind is not unusual for a task requiring an overt response following an anticipatory interval of 10 sec, in this case between slide onset and rating signal.

In evaluating subjects' electrodermal response to the stimulus slides, SCR magnitude in the first response period, or MAG1, was of primary interest. In addition, three other measures of electrodermal activity were analyzed: MAG2, magnitude of the largest SCR in the second response period (5–11 sec after slide onset); MAG, magnitude of the largest SCR in the entire 1–11-sec period; and SCL, the level of skin conductance measured at slide onset. Skin conductance records for one subject were not scorable due to equipment malfunction.

Heart rate. Prestimulus HR and average HR per second for 13 post-slide sec were computed from the printed R–R interval data.[4] The triphasic cardiac response during the first 10 sec after slide onset consisted of a 1-sec deceleration (D1), an acceleratory limb (A1) peaking at approximately 4 sec, and an anticipatory deceleration (D2) at approximately 9 sec. This waveform is typical of cardiac responses during such intervals preceding expected stimuli and/or responses. All three peaks—D1, A1, and D2—were significant by *t* tests on HR changes from prestimulus during each post-stimulus second. A subsequent acceleration, still rising at 13 sec, was also significant by this test and was most likely produced by vocalizations following the rating signal (cf. Campos & Johnson, 1966; Libby et al., 1973, p. 288). Subsequent analyses treated four indices of cardiac activity on each trial: The D1, A1, and D2 peaks (i.e., HR change from prestimulus at post-stimulus sec 1, 4, and 9, respectively) and prestimulus HR.

Facial expressiveness. For each facial response to a slide presentation, four measures of facial expressiveness were computed. These consisted of the judges' mean ratings, based on the 10- and the 30-sec videotaped segments, of facial pleasantness (PL10 and PL30, respectively), and of facial intensity (INT10 and INT30).

---

[4] The preslide value of HR was taken to be the HR value during the cardiac cycle just prior to the one in which slide onset occurred. Thus prestimulus HR was uncontaminated by stimulus-evoked activity but the first "poststimulus" second could contain almost an entire preslide cardiac cycle.

RESULTS

Effects of Slide Category

The effects of the five a priori slide categories—sexual, scenic, pleasant, unusual, and unpleasant—were evaluated in one-way ANOVAs on category means of 13 dependent measures. These included the four electrodermal measures (MAG, MAG1, MAG2, and prestimulus SCL), the four cardiac measures (D1, A1, D2, and prestimulus HR), the four ratings of facial response (PL10, PL30, INT10, INT30), and subjects' own ratings of slide pleasantness. These analyses, summarized in Table 1, included three nonorthogonal comparisons which contrasted sexual-vs-unpleasant, sexual-vs-pooled scenic, unusual, and pleasant, and unpleasant-vs-pooled scenic, unusual, and pleasant slide catgories.

Not surprisingly, subjects' own ratings of slide pleasantness were highest to sexual and scenic slides and lowest to the unpleasant slides (see Table 1). The effect of slide category was highly significant[5], as were all three special comparisons, indicating that the middle categories (unusual, pleasant, and scenic) were less pleasant than the sexual but more pleasant than the unpleasant category.

Second-by-second HR responses to the five categories of slides are presented in Fig. 1. Although the triphasic response pattern is apparent in each waveform, the sexual and unpleasant categories produced responses that differed markedly both from each other and from the other three. Statistically, the effect of slide category was significant only for A1, the accelerative peak at 4 sec (see Table 1), so the other three cardiac measures are not discussed further. The special comparisons revealed that the A1 response was significantly lower to unpleasant slides than to either the sexual or to the pooled middle categories.

As with HR A1, slide category significantly affected all three indices of SCR magnitude (Table 1). But whereas HR A1 was smallest to unpleasant slides, paralleling subjects' own pleasantness ratings, this was not the case for skin conductance. Instead of a diminished response, we see that the magnitude of SCR in the unpleasant category was second only to that of the sexual category. This was particularly the case for MAG and MAG1, where special comparisons showed smaller responses in the pooled middle categories than in either sexual or unpleasant conditions, but no difference between the latter two.

Table 1 also shows that judges' ratings of facial pleasantness increased from unpleasant to sexual slide categories, paralleling subjects' own pleasantness ratings and HR A1 response. The main effect of slide category, and all three comparisons, were highly significant for both 10- and 30-sec judgments. Facial intensity, on the other hand, more closely resembled

[5] For all results termed significant here and elsewhere in this paper, $p < .05$.

TABLE 1
EFFECTS OF SLIDE CATEGORY ON PHYSIOLOGICAL, FACIAL, AND SELF-REPORTED RESPONSES
SUMMARY OF SIGNIFICANT EFFECTS

Dependent measure	Slide category means					Slide category effect			Special comparisons of slide categories							
	1 Un-pleasant	2 Un-usual	3 Pleas-ant	4 Scenic	5 Sexual				1 vs 5			5 vs 2, 3, 4		1 vs 2, 3, 4		
						df	*MSE*	*F*	*df*	*MSE*	*F*	*MSE*	*F*	*MSE*	*F*
HR A1[a]	−.82	1.72	1.35	1.25	4.10	4,76	15.89	3.85*	1,19	25.41	9.51*	27.28	3.88	11.65	6.58*
SCR MAG[b]	1.18	.76	.59	.53	1.55	4,72	0.28	12.52*	1,18	.39	3.28	.79	15.27*	.23	18.93*
SCR MAG1[b]	.98	.62	.49	.37	1.16	4,72	0.17	12.58*	1,18	.21	1.47	.29	21.98*	.25	13.12*
SCR MAG2[b]	.40	.28	.23	.26	.81	4,72	0.17	6.24*	1,18	.31	4.98*	.49	8.81*	.08	3.94
Slide pleas-antness[c]	1.43	4.35	4.70	5.84	5.83	4,76	0.41	159.30*	1,19	.52	372.96*	.67	16.68*	.36	519.84*
PL 10[c]	2.96	3.59	3.80	3.67	4.33	4,76	0.34	13.88*	1,19	.62	30.09*	.34	17.96*	.42	18.47*
PL 30[c]	2.96	3.60	3.93	3.93	4.41	4,76	0.28	20.23*	1,19	.60	34.75*	.49	10.88*	.31	35.18*
INT 10[c]	4.08	3.65	3.92	3.74	3.88	4,76	0.25	2.20	1,19	.32	1.19	.20	.96	.46	3.09
INT 30[c]	4.42	3.87	3.86	3.93	4.16	4,76	0.14	7.95*	1,19	.21	3.23	.14	7.74*	.30	14.07*

Note. Units: [a] = changes in bpm; [b] = μmho; [c] = 1–7 rating scale where 7 is most pleasant or most intense. No significant effects were found for HR D1, HR D2, prestimulus HR, or prestimulus SCL so these measures are not included here.

* Significant at .05 level or beyond.

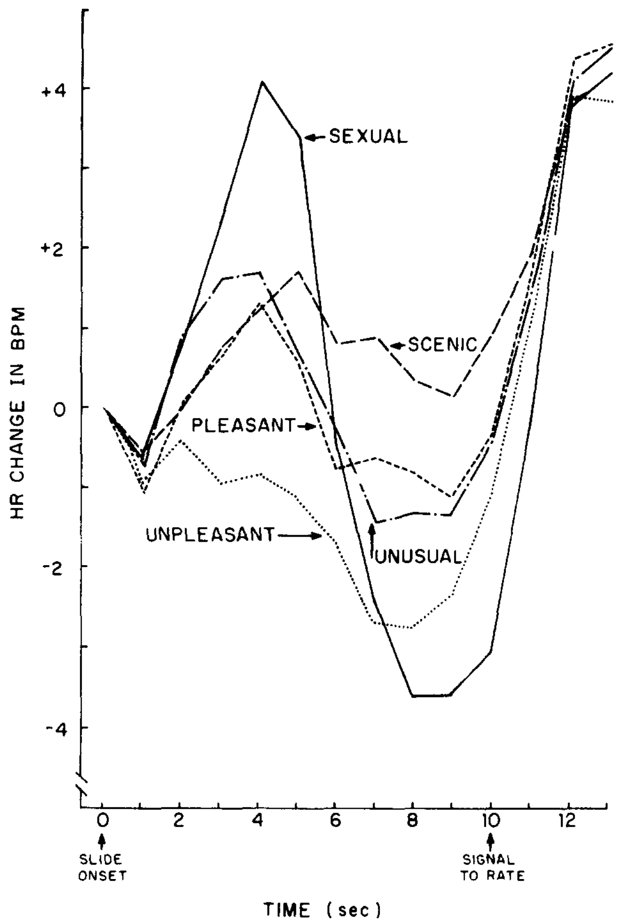

FIG. 1. Second-by-second changes in heart rate as a function of slide category.

skin conductance MAG and MAG1 in that it was similarly large in sexual and unpleasant conditions. The main effect of slide category was significant only for 30-sec judgments, as were the comparisons between the middle categories and both the sexual and unpleasant categories.

Effects of Slide Pleasantness

The preceding analyses suggest a correspondence between the decreasing ratings of slide pleasantness from sexua' to unpleasant slide categories and the decreases in both HR A1 and in judged facial pleasantness. Skin conductance responses and facial intensity ratings, on the other hand, appear largest in the categories receiving pleasantness ratings at either extreme. To more directly evaluate these apparent relationships, another set of one-way ANOVAs was carried out on the same 12 physiological and facial response indices, this time treating the subjects' own ratings of slide pleasantness as the independent variable. For each dependent measure, we computed the mean value for each subject at each of seven levels of self-reported pleasantness. The linear, quadratic, and cubic components of trend across the 7-point rating scale were then evaluated in order to examine the relationship between self-reported affect and physiological and facial responding.

All three response systems—cardiac, electrodermal, and facial—showed systematic relationships to self-rated slide pleasantness. The nature of the relationship was not always the same, however. Considering the physiological measures, the effect of slide pleasantness was significant for both SCR MAG1, $F(6, 108) = 2.98$, and for HR A1, $F(6, 114) = 2.23$. Interestingly, A1 increased linearly with slide pleasantness, $F_{lin}(1, 19) = 8.30$, while MAG1 was greatest at the extremes and showed a quadratic trend, $F_{quad}(1, 18) = 8.42$. Figure 2 illustrates this difference. Slide pleasantness did not systematically affect either the early or late HR decelerations or the second-interval SCR; its effect on SCR MAG paralleled that on SCR MAG1. As in the slide category analyses, neither cardiac nor electrodermal prestimulus measures differed as a function of slide pleasantness.

Both the 10- and 30-sec judgments of facial expressiveness were significantly affected by slide pleasantness ($F(6, 114) = 9.54, 21.50, 2.39$, and 8.76 for PL10, PL30, INT10, and INT30, respectively), but the nature of the relationship differed for pleasantness and intensity. As Fig. 3

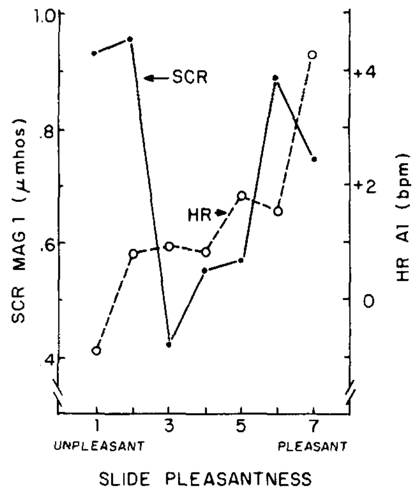

FIG. 2. Magnitude of skin conductance responding in the first response period (1 to 5 sec after slide onset), and HR change from prestimulus at post-slide sec 4, as a function of self-reported slide pleasantness.

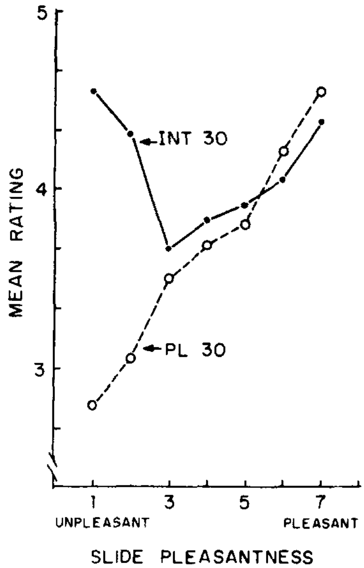

FIG. 3. Judges' ratings of facial pleasantness (PL 30) and facial intensity (INT 30), based on 30-sec videotaped segments, as a function of self-reported slide pleasantness.

shows, facial pleasantness increased with slide pleasantness, while facial intensity was greatest at the extremes of the slide pleasantness scale. These impressions were substantiated by significant linear trends for PL10 and PL30, $F_{lin}(1, 19) = 19.72$ and 48.17, but significant quadratic trends for INT10 and INT30, $F(1, 19) = 7.68$ and 24.13. All other effects were nonsignificant.

Relationships between Facial Expressiveness and Physiological Responses

Evidence for the discharge model presented by Buck and colleagues (1972, 1974, 1977) has been based on between-subjects correlations, in which single indices of expressiveness and physiological reactivity are computed for each subject, and correlations are then computed across subjects. To facilitate comparison with the work of these researchers, we calculated Communication Accuracy (CA) scores which are analogous to the "Pleasantness Measures" they have used. These CA scores are product-moment correlations between the mean judged facial pleasantness and the subject's self-reported pleasantness on each trial.

All 20 of the CA scores based on 30-sec judgments were positive, 17 were significantly greater than zero ($p < .05$, one-tailed), and the median $r = .50$. For CA scores based on 10-sec judgments, 11 were significantly greater than zero and the median $r = .38$.

We then computed product-moment correlations between the CA scores and three indices of physiological reactivity: HR A1 response in beats per minute, SCR MAG1 in μmhos, and a frequency measure of skin conductance responding comparable to the one used by Buck and colleagues. The last was computed as follows: (SCR frequency 1–11 sec postslide) − (SCR frequency 0–8 sec preslide)/(No. of trials). The discharge model would predict generally negative between-subjects correlations between CA and physiological reactivity. However, these correlations ranged from .06 to .30 in the present study. Thus, contrary to the findings of Buck and colleagues, we find no evidence of a negative relationship between expressiveness and physiological reactivity. To the contrary, a zero-order or weak positive relation is suggested, although none of the correlations is significant.[6] Inspection of scatterplots did not reveal any apparent curvilinear trends.

DISCUSSION

Both visceral responses and facial expressions evoked by affective slides carried information about evaluation and intensity, the dimensions underlying emotional experience. As illustrated in Figs. 2 and 3, the cardiac A1 response and judges' ratings of facial pleasantness were monotonically related to subjects' self-reported pleasantness of affect. Electrodermal responding and judges' intensity ratings were curvilinearly related to self-rated pleasantness; both measures were highest at the extremes of the pleasantness scale. These results have been replicated in two recent slide-rating studies. Putnam, Winton, and Krauss (1982) reported similar effects of affective pleasantness on facial expression, SCR and HR responses in the "Natural" condition of a study in which male subjects were instructed to respond naturally on some trials but to dissimulate (i.e., display the opposite emotion) on others. Putnam and

[6] We serendipitously discovered that laterborns (n = 10) had higher CA scores than firstborns (n = 10). We calculated mean CA scores by converting to z scores, taking the mean, and then converting back to r's (recall that the CA scores are themselves Pearson product–moment correlations). For CA scores based on 30-sec judgments, r(Laterborns) = .60 and r(Firstborns) = .39; $t(18) = 2.29$, $p < .05$, two-tailed. For 10-sec judgments, r(Laterborns) = .44 and r(Firstborns) = .27; $t = 1.35$, n.s. That laterborns are more expressive may reflect their greater sociability (cf. Schachter, 1964). This discovery led us to compute correlations between CA and physiological reactivity separately for the two groups. To our surprise, a striking difference emerged with regard to the correlations between CA and HR A1. For CA scores based on 30-sec judgments, r(Firstborns) = −.56 and r(Laterborns) = .78. For those based on 10-sec judgments, r(Firstborns) = −.57 and r(Laterborns) = .61. In each instance, the value for laterborns is significantly greater than the corresponding value for firstborns (for 30-sec judgments, $z = 3.14$, $p < .005$; for 10-sec judgments, $z = 2.53$, $p < .02$). Inspection of scatterplots suggested that each correlation is heavily influenced by one or two outlying points—not surprising considering the small sample size. For this reason, we have little confidence in the replicability of this birth order difference.

Rennert (1983) replicated the autonomic effects in normal-weight but not obese females; in that study, facial expressions were not recorded.

The relationship of phasic HR change to affective pleasantness replicates the findings of Libby et al. (1973), in spite of important differences in procedure. In the Libby et al. study, subjects viewed (but did not rate) 30 slides similar to those employed in the present study, while their cardiac and pupillary responses were monitored. The slides had been previously rated on 22 semantic differential scales which, when factor analyzed, yielded four factors. Two of the factors, attention–interest and pleasantness–evaluation, while independent of each other, were significantly related to the cardiac response evoked by the slides. This response was characterized by a monophasic deceleration peaking approximately 5 sec after slide onset. The magnitude of this deceleration increased with increasing attention–interest, but with decreasing pleasantness, of the evoking slides.

The present study departed significantly from the passive viewing procedure of Libby et al., by imposing a rating requirement 10 sec after slide onset. It is well documented that the addition of such a response requirement changes the cardiac waveform by adding an acceleratory component several seconds after slide onset (e.g., Hare, 1972; Klorman, Weisenfeld, & Austin, 1975). This is clearly evident in the present HR data (see Fig. 1) and contrasts markedly with the monophasic decelerations of Libby et al. (1973, Figs. 6 & 7). In addition, the 10-sec interval between slide onset and rating signal in the present study further altered the cardiac waveform by producing a late deceleratory response (D2). In spite of these differences in procedure, and the resulting differences in the cardiac waveform, the magnitude of HR change 4 sec after slide onset (A1) (the only component associated with affective pleasantness) replicated the Libby et al. (1973) finding in that it became increasingly decelerative (or decreasingly accelerative) with increasing unpleasantness (see Fig. 2).

The fact that HR responses 4 or 5 sec post-stimulus show the same relationship to pleasantness/evaluation with or without a rating requirement suggests that the rating task does not mask or distort the cardiac–affect relationship, but merely adds a constant acceleratory influence across conditions. This acceleratory influence presumably reflects the additional cognitive and response-preparation requirements imposed by the rating task (Libby et al., 1973). Assuming that these cognitive requirements did not vary with slide pleasantness, they may have simply added a constant degree of acceleration to what would otherwise have been a primarily decelerative response to the slides.

The pattern of HR acceleration to pleasant and deceleration to unpleasant stimuli is not limited to responses to female nudes and mutilated bodies. Power, Hildebrandt, and Fitzgerald (1982) obtained similar results in a study where subjects rated slides of infants. The cardiac waveforms of male subjects during the first 4 sec after stimulus onset were almost identical to those of the present study, with smiling and crying infants eliciting acceleratory and deceleratory responses, respectively.

Numerous other studies have reported HR deceleration to unpleasant stimuli (e.g., Cacioppo & Sandman, 1978; Hare, 1972; Hare, Wood, Britain, & Frazelle, 1971; Hare, Wood, Britain, & Shadman, 1970; Klorman et al., 1975; Klorman, Weissberg, & Weisenfeld, 1977). Cardiac deceleration in conjunction with increases in skin conductance (as occurred in the present study) is an example of what Lacey has termed directional fractionation of autonomic response systems (e.g., Lacey, 1959, 1967). Several investigators have suggested that directional fractionation of cardiac and electrodermal responses no longer occurs when a rating task is imposed, because HR becomes acceleratory under these conditions (Campos & Johnson, 1967; Edwards & Alsip, 1969; Hare, 1972). In the present study, however, directional fractionation occurred in spite of the acceleratory influence of the rating task. Figure 2 illustrates this dissociation, showing that affective pleasantness is linearly related to the HR A1 response, but curvilinearly related to SCR magnitude.

Hare et al. (1971) suggested that cardiac deceleration to unpleasant stimuli reflects "morbid fascination," i.e., an attentional response due to the unpleasantness of the stimuli. If one accepts this attentional interpretation of the HR response to unpleasantness, one must also interpret the response to pleasant stimuli in attentional terms. Since both Libby et al. (1973) and the present study found decreasing HR deceleration (or increasing HR acceleration) as stimulus pleasantness increased, such a view would hold that attention decreased with stimulus pleasantness. While it is not inconceivable that reduced sensory intake characterizes our response to very pleasant stimuli, it is more plausible, and equally consistent with the data, to view these findings in nonattentional terms. Although the sensitivity of phasic HR change to attentional manipulations is well documented (e.g., Graham & Clifton, 1966), the present data as well as those of Libby et al. (1973) suggest that HR change may also reflect the valence of affective response, independent of attentional response.

If skin conductance had been our sole measure of physiological reactivity, one might have concluded that our results support Schachter and Singer's (1962) theory of emotion. As Fig. 2 shows, SCR is high in extreme self-report categories and low in moderate categories. If one considers SCR an index of generalized arousal, the results are precisely what the Schachter–Singer model would predict.

Joint consideration of SCR and HR (Fig. 2) suggests a different conclusion. Extreme pleasantness (self-report category 7) is characterized by high values of both SCR and HR, while extreme unpleasantness (self-report category 1) is characterized by high SCR values but depressed values of HR. That is to say, different feeling states correspond to different patterns of physiological activity. Of course our study employed a narrow range of emotion-eliciting stimuli. But to the extent that such patterns of differentiated physiological activity are characteristic across the spectrum of emotional experience, our findings are more consistent with the James–Lange theory, and conceptually similar approaches.[7]

Of course, the physiological responses we have observed have too great a latency to be themselves the visceral responses directly responsible for emotional experience, an objection raised by Cannon to the original formulation of the James–Lange theory. Cannon's objection was based partly on Well's (1925) observation that self-reported affective responses to visual stimuli occurred within 800 msec of stimulus presentation, which suggested that visceral reactions with a latency of 3–4 sec were too slow to be the source of the affect. Contemporary investigators have come to similar conclusions. Chapman, McCrary, Chapman, and Martin (1980) found that emotion words connoting such qualities as pleasantness–unpleasantness produced distinctive patterns of evoked potentials in the brain within 510 msec after presentation. Thus it is possible that a central mechanism is responsible for both emotional experience and the physiological responses we have observed.

While our results do not support the Schachter–Singer explanation of emotional experience, neither do they offer much comfort to recent critics of that approach. For example, Marshall and Zimbardo (1979) and Maslach (1979) argue that the experience of arousal fosters a negative emotional state. An examination of our SCR data (Table 1) provides apparent support for this position. For the four nonsexual slide categories, the greatest SCR changes occur in response to slides previously characterized as unpleasant,[8] and these slides are also rated as unpleasant in subjects' self-reports. However, simultaneous examination of HR and SCR provides no support for the notion of "negatively biased arousal." Increments in both HR and SCR are observed only for the unusual, pleasant, and scenic categories, all of which are rated toward the pleasant end of the scale: for unpleasant slides, we find a decrease in HR accompanying an increase in SCR.

[7] Schachter and Singer's assumption of undifferentiated arousal has been criticized by several authors, including Lang (1971), Lykken (1967), Shapiro and Schwartz (1970), and Stein (1967). However, Mandler (1975) defended such an assumption, contending that studies of physiological patterning have not demonstrated that emotion is a function of such patterns.

[8] A discussion of Marshall and Zimbardo and of Maslach could be based on Fig. 2, but that figure includes responses to sexual pictures, and Maslach (1979, p. 955) suggested that the state of sexual excitement might constitute an exception to their views. Acknowledging Maslach's caveat, it is best to evaluate their notion of "negatively biased arousal" by referring to Table 1, so that the effects of the four nonsexual slide categories can be considered by themselves.

Our results bring into question the utility of a unidimensional view of physiological arousal. Much social psychological research on the facial feedback and discharge models rests on a unidimensional conception of physiological arousal. The facial feedback notion is often taken to imply that arousal should increase with expressiveness, while the discharge model is interpreted as predicting a decrease in arousal as overt expressiveness intensifies (Buck, 1980; Zuckerman, Klorman, Larrance, & Spiegel, 1981). Interpreted thusly, neither theory can accomodate the dissociation between response systems observed in the present study. If a stimulus can produce an increase in electrodermal responding and a simultaneous decline in HR, it makes little sense to ask whether the stimulus produced an increase or a decrease in autonomic responding. The results of the present study suggest that a multidimensional conception of arousal provides a more useful way of characterizing the internal responses to emotional stimuli. A similar conclusion has been reached by Schwartz, Davidson, and Pugash (1976) and Tourangeau and Ellsworth (1979).

Finally, our results point to a provocative possibility that deserves further consideration. Our between-subjects results indicate a roughly linear relationship between HR and judged facial pleasantness; SCR and judged facial intensity seem to be similarly related. It will be recalled from our earlier discussion that these two judged dimensions (or ones quite similar to them) consistently emerge from scaling studies as the primary dimensions accounting for the structure of the space for facial expressions of emotions and emotion words. And it will also be recalled that these two dimensions provide a reasonable degree of differentiation, at least among the primary emotions. The intriguing possibility these results suggest is that these two physiological variables reflect an internal source of differentiation among qualitatively different feeling states.

The problem with this is that phenomenologically our experience of emotions is distinctly categorical. Anger and fear, for example, are experienced as qualitatively different emotions, although they are both very intense and highly unpleasant. While it must be granted that stimuli which vary dimensionally can be experienced categorically (as is the case with nonmonochromatic color), perhaps a more plausible approach would retain the essence of the Schachter–Singer model, but modify its particulars. Such an approach would posit a bidimensional model of emotional arousal that provides internal information on both the intensity and the evaluative quality of the affect being experienced, in contrast to the Schachter–Singer unidimensional view of internal arousal as a source only of intensity information. The role of cognition would be to enable the individual to identify the specific category of emotional experience on the basis of the eliciting circumstances.

REFERENCES

Buck, R. (1977). Nonverbal communication of affect in preschool children: Relationships with personality and skin conductance. *Journal of Personality and Social Psychology,* **35,** 225–236.

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

Buck, R., Miller, R. E., & Caul, W. F. (1974). Sex, personality, and physiological variables in the communication of affect via facial expression. *Journal of Personality and Social Psychology,* **30,** 587–596.

Buck, R., Savin, V. J., Miller, R. E., & Caul, W. F. (1972). Communication of affect through facial expressions in humans. *Journal of Personality and Social Psychology,* **23,** 362–371.

Cacioppo, J. T., & Sandman, C. A. (1978). Physiological differentiation of sensory and cognitive tasks as a function of warning, processing demands, and reported unpleasantness. *Biological Psychology,* **6,** 181–192.

Campos, J. J., & Johnson, H. J. (1966). The effects of verbalization instructions and visual attention on heart rate and skin conductance. *Psychophysiology,* **2,** 305–310.

Cannon, W. B. (1927). The James–Lange theory of emotions: A critical examination and an alternative theory. *American Journal of Psychology,* **39,** 106–124.

Chapman, R. M., McCrary, J. W., Chapman, J. A., & Martin, J. K. (1980). Behavioral and neural analyses of connotative meaning: Word classes and rating scales. *Brain and Language,* **11,** 319–339.

Cooper, J., Fazio, R. H., & Rhodewalt, F. (1978). Dissonance and humor: Evidence for the undifferentiated nature of dissonance arousal. *Journal of Personality and Social Psychology,* **36,** 280–285.

Darwin, C. (1955). *The expression of the emotions in man and animals.* New York: Philosophical Library, 1955. (Original work published 1872.)

Edwards, D. C., & Alsip, J. E. (1969). Intake-rejection, verbalization, and affect: Effects on heart rate and skin conductance. *Psychophysiology,* **6,** 6–11.

Ekman, P., Friesen, W. V., & Ellsworth, P. (1972). *Emotion in the human face.* New York: Pergamon.

Gaertner, S. L., & Dovidio, J. F. (1977) The subtlety of white racism, arousal, and helping behavior. *Journal of Personality and Social Psychology,* **35,** 691–707.

Gellhorn, E. (1964). Motion and emotion: The role of proprioception in the physiology and pathology of the emotions. *Psychologial Review,* **71,** 457–472.

Graham, F. K., & Clifton, R. K. (1966). Heart rate changes as a component of the orienting response. *Psychological Bulletin,* **65,** 305–320.

Graham, F. K., & Jackson, J. C. (1970). Arousal systems and infant heart rate responses. In H. W. Reese & L. P. Lipsitt (Eds.), *Advances in Child Development and Behavior,* **5,** 59–117.

Hare, R. D. (1972). Response requirements and directional fractionation of autonomic responses. *Psychophysiology,* **9,** 419–427.

Hare, R., Wood, K., Britain, S., & Frazelle, J. (1971). Autonomic responses to affective visual stimulation: Sex differences. *Journal of Experimental Research in Personality,* **5,** 14–22.

Hare, R., Wood, K., Britain, S., & Shadman, J. (1970). Autonomic responses to affective visual stimulation. *Psychophysiology,* **7,** 408–417.

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

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

Jackson, J. (1974). Amplitude and habituation of the orienting reflex as a function of stimulus intensity. *Psychophysiology,* **11,** 647–659.

James, W. (1884). What is an emotion? *Mind,* **9,** 188–205.

James W. (1950). *The principles of psychology*. New York: Dover. (Original work published 1890.)

Jones, H. E. (1935). The galvanic skin reflex as related to overt emotional expression. *American Journal of Psychology,* **47,** 241–251.

Jones, H. E. (1950). The study of patterns of emotional expression. In M. L. Reymert (Ed.), *Feelings and emotions*. New York: McGraw-Hill.

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

Klorman, R., Weisenfeld, A. R., & Austin, M. L. (1975). Autonomic responses to affective visual stimuli. *Psychophysiology,* **12,** 553–560.

Klorman, R., Weissberg, R. P., & Weisenfeld, A. R. (1977). Individual differences in fear and autonomic reactions to affective stimulation. *Psychophysiology,* **14,** 45–51.

Lacey, J. I. (1959). Psychophysiological approaches to the evaluation of psychotherapeutic process and outcome. In E. A. Rubinstein & M. B. Parloff (Eds.), *Research in psychotherapy*. Washington, DC: American Psychological Association.

Lacey, J. I. (1967). Somatic response patterning and stress: Some revisions of activation theory. In M. H. Appley & R. Trumbull (Eds.), *Psychological stress: Issues in research*. New York: Appleton–Century–Crofts.

Lacey, J. I., Kagan, J., Lacey, B. C., & Moss, H. A. (1963). The visceral level: Situational determinants and behavioral correlates of autonomic response patterns. In P. Knapp (Ed.), *Expression of the emotions in man*. New York: International Univ. Press.

Lacey, J. I., & Lacey, B. C. (1958). The relationship of resting autonomic activity to motor impulsivity. In H. C. Solomon, S. Cobb, & W. Pennfield (Eds.), *The brain and human behavior* (Vol. 36). Baltimore: Williams & Wilkins.

Lacey, J. I., & Lacey, B. C. (1970). Some autonomic–central nervous system interrelationships. In P. Black (Ed.), *Physiological correlates of emotion*. New York: Academic Press.

Lacey, J. I., & Lacey, B. C. (1974). On heart rate responses and behavior: A reply to Elliott. *Journal of Personality and Social Psychology,* **30,** 1–18.

Lang, P. J. (1971). The application of psychophysiological methods to the study of psychotherapy and behavior modification. In A. E. Bergin & S. L. Garfield (Eds.), *Handbook of psychotherapy and behavior change*. New York: Wiley.

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.

Libby, W. L., Jr., Lacey, B. C., & Lacey, J. I. (1973). Pupillary and cardiac activity during visual attention. *Psychophysiology,* **10,** 270–294.

Lykken, D. T., (1967). "Emotionality and autonomic reactivity": An appraisal. *Journal of Experimental Research in Personality,* **2,** 49–55.

Malmo, R. B. (1959). Activation: A neuropsychological dimension. *Psychological Review,* **66,** 367–386.

Mandler, G. (1975). *Mind and emotion*. New York: Wiley.

Marshall, G. C., & Zimbardo, P. G. (1979). Affective consequences of inadequately explained physiological arousal. *Journal of Personality and Social Psychology,* **37,** 970–988.

Maslach, C. (1979). Negative emotional biasing of unexplained arousal. *Journal of Personality and Social Psychology,* **37,** 953–969.

Notarius, C. I., & Levenson, R. W. (1979). Expressive tendencies and physiological response to stress. *Journal of Personality and Social Psychology,* **37,** 1204–1210.

Olson, C. T. (1978). *The effect of perceived conditions of interpersonal observation on encoding and decoding processes during deceitful self-presentation*. Unpublished doctoral dissertation, Columbia University.

Patterson, M. (1976). An arousal model of interpersonal intimacy. *Psychological Review*, **83**, 235–245.

Power, T. G., Hildebrandt, K. A., & Fitzgerald, H. E. (1982). Adults' responses to infants varying in facial expression and perceived attractiveness. *Infant Behavior and Development*, **5**, 33–44.

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

Putnam, L., & Rennert, M. (1983). Psychophysiological responses to affective stimuli in obese and normal-weight women. *Psychophysiology*, **20**, 463. (Abstract)

Russell, J. A. (1981). A circumplex model of affect. *Journal of Personality and Social Psychology*, **39**, 1161–1178.

Schachter, S. (1964). Birth order and sociometric choice. *Journal of Abnormal and Social Psychology*, **68**, 453–456.

Schachter, S., & Singer, J. (1962). Cognitive, social, and physiological determinants of emotional state. *Psychological Review*, **69**, 379–399.

Schaeffer, G. H., & Patterson, M. L. (1980). Intimacy, arousal, and small group crowding. *Journal of Personality and Social Psychology*, **38**, 283–290.

Schlosberg, H. (1941). A scale for the judgment of facial expressions. *Journal of Experimental Psychology*, **29**, 497–510.

Schlosberg, H. (1954). Three dimensions of emotion. *Psychological Review*, **61**, 81–88.

Schwartz, G. E., Davidson, R. J., & Pugash, E. (1976). Voluntary control of patterns of EEG parietal asymmetry: Cognitive concomitants. *Psychophysiology*, **13**, 498–504.

Shapiro, D., & Schwartz, G. E. (1970). Psychophysiological contributions to social psychology. *Annual Review of Psychology*, **21**, 87–112.

Stein, M. (1967). Some psychophysiological considerations of the relationship between the autonomic nervous system and behavior. In D. C. Glass (Ed.), *Neurophysiology and emotion*. New York: Rockefeller Univ. Press/Russell Sage Foundation.

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

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

Wells, F. L. (1925). Reactions to visual stimuli in affective settings. *Journal of Experimental Psychology*, **8**, 64–76.

Woodworth, R. S. (1938). *Experimental psychology*. New York: Holt.

Worchel, S., & Teddlie, C. (1976). The experience of crowding: A two-factor theory. *Journal of Personality and Social Psychology*, **34**, 30–40.

Worchel, S., & Yohai, S. M. L. (1979). The role of attribution in the experience of crowding. *Journal of Experimental Social Psychology*, **15**, 91–104.

Zanna, M. P., & Cooper, J. Dissonance and the pill: An attribution approach to studying the arousal properties of dissonance. *Journal of Personality and Social Psychology*, **29**, 703–709.

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