Title
Psychophysiological response patterns of emotion

Author
Ancoli-Israel, Sonia

Publication Date
1979

Peer reviewed|Thesis/dissertation

PSYCHOPHYSIOLOGICAL RESPONSE

PATTERNS OF EMOTION

by

Sonia Ancoli
B.A. State University of New York, Stony Brook 1972
M.A. California State University, Long Beach 1974

DISSERTATION

Submitted in partial satisfaction of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Psychology

in

GRADUATE DIVISION

of the

UNIVERSITY OF CALIFORNIA

San Francisco

[redacted]

Date Librarian

Degree Conferred: JUN 24 1979

Psychophysiological Response Patterns of Emotion

Sonia Ancoli

University of California, San Francisco

ABSTRACT

The major conclusions of this study contradict much of the previous research on the psychophysiological differentiation of emotion. One of the accepted views has been that of general physiological arousal responses to emotion. Our results indicate that the physiological responses to a positive emotional stimulus (pleasant film) are different from the physiological responses to a negative emotional stimulus (unpleasant film).

In addition, our methodology allowed us to show why some other studies found no physiological differentiation while our study did. Previous research assumed that all subjects would respond to a single stimulus with the same emotion. Our results indicated that the films did not elicit the same emotion. Previous research also presumed that the emotion elicited lasted for the entire duration of the stimulus. Our results indicated that the emotional responses did not last for the duration of the films.

Our data were collected by taking continuous psychophysiological measurements of EEG (right and left central and temporal), muscle tension (trapezious and pectoralis EMG), basal skin resistance (BSR), heart rate (HR), and thoracic and abdominal respiration in 35 females while each watched a pleasant and an unpleasant film. Standardized

questionnaires were given to determine the extent to which each subject experienced different emotions (self-reports). Unbeknownst to the subjects, their faces were videotaped. The Facial Action Coding System (FACS) was used to score the facial responses and objectively determine which emotions were being expressed facially by the subjects.

Film, facial response and self-report were the independent measures used. The physiological responses were the dependent measures. Emotion was measured in four ways for purposes of examining the physiological differences between positive and negative emotions: 1) by film alone; 2) by film and facial response; 3) by film and self-report; 4) by film, facial response and self-report.

When our data were analyzed in the same manner as the data of studies supporting the general arousal theory, we reproduced their findings The physiological data were first averaged over the 3 minute and 2 minute films. There were no significant physiological differences. However, when we utilized an independent variable (the facial responses) to determine what emotion was present, when emotion was present, and in which subjects the emotion was present, the analyses revealed findings not previously found.

For statistical analysis, subjects were classified into different groups according to the ways of specifying the emotions (as defined in the four ways listed above). The physiological data were then averaged for the 5 seconds immediately preceding a facial response (Before Facial Response period) and for the first 5 seconds of the facial response (During Facial Response period). The Before- and During Facial Response periods were then compared to each other and to baseline.

The following results emerged, regardless of how subjects were classified:

1. Heart rate ($p=.03$) significantly increased from baseline to the Before Facial Response period in the pleasant film;

2. Heart rate ($p=.02$) significantly increased from baseline to the During Facial Response period in the unpleasant film;

3. Heart rate ($p=.008$) and thoracic respiration ($p=.02$) significantly increased from the Before- to the During Facial Response period in the unpleasant film;

4. Basal skin resistance ($p=.05$) significantly decreased from the Before- to the During Facial Response period in the unpleasant film.

In addition, the results led to the conclusion that to find physiological differentiation of emotion, an independent variable such as the face must be used to pinpoint small time epochs of emotion.

There were no significant EEG or EMG results.

This study further supports the theory that there are different psychophysiological response patterns for positive and negative emotions. By using independent indices of emotion, it becomes possible to study the extent of this differentiation.

ACKNOWLEDGEMENTS

This study would never have been completed without the help of numerous people. My sincerest appreciation goes to:

Nissan and Esther Ancoli, who gave me the education that only parents can give and the total love and confidence that taught me that I could achieve any goal. My success is also their success.

Dr. Andrew G. Israel, who shared the highs and the lows with me, and gave me his love and support throughout my madness and despite my madness.

My committee, made up of three people who each in their own way helped me to grow. At every stage of the way, they were there, sometimes with suggestions, sometimes with criticisms, but always with support. They made it clear that they thought highly of me as a scientist and that is what kept me going through all the equipment failures, computer breakdowns, and rewrites. I truly love and respect each of them:

Dr. Joe Kamiya, my chairman and mentor, who helped me become a psychophysiologist. I will always remember the long hours he spent talking, teaching and working with me side by side;

Dr. Paul Ekman, who warned me I was biting off too much, but knowing that I wouldn't do it any other way, kept pushing me back up when my energy got low. Paul taught me about emotion and about the face, and through it all remained my friend. There will always be an AU 6 + 12z for him;

Dr. Shirley Peeke, who lent a special balance to the entire process and who taught me how to be persistant in a gentle manner.

Dr. Phoebe Ellsworth for giving me copies of her film; Drs. Bob Feinberg, Van Peeke, and George Stone for loaning me their equipment.

Allan Bostrom*, Mark Dedon, Joe Doyle, and Hilary Naylor for their computer assistance; Dennis Hall and Mark Spitalny* for the long hours they spent making the programs work; Alan Gevins and the EEG Systems Group for allowing me the use of their computer and programs.

Dr. Linda Camras for her help in scoring all those faces.

Dr. Wally Friesen, Dr. Jim Johnston, Joanne Kamiya, Dr. Karen Naifeh and Dr. Sheelah Sigel for their help, each in their own special way.

Nellie Cady and R. Marty Kamp for always finding funds when I thought there couldn't possibly be any left. This study was supported by the Earl C. Anthony Fund, Patent Funds, BRSG Funds, and the UCSF Instructional Use of Computer Funds.

Special appreciation also goes to the 35 women who volunteered to be my subjects and who really make up this study.

* Scientific Computing Center, University of California, San Francisco.

TABLE OF CONTENTS

Page

Chapter

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This study explored how certain emotions differ physiologically. In pursuit of this question, various methodologies were used.

There are two views on the physiological correlates of emotion. The first view point was fathered by James (1884). James believed that emotion is differentiated physiologically. Ax (1953) has recently supported this view. The second school of thought was fathered by Cannon (1927). Cannon believed that the physiological changes accompanying emotion are always general arousal responses which are undifferentiated. Mandler (1975) and Schachter (1962) support this second view.

These two schools of thought separate the psychophysiologists from the cognitive psychologists. A basic premise of psychophysiology is that for every change in the mental and emotion state, there may be a corresponding change in the physiological state. Therefore, the overall question, rather than being, "Do different emotions have different psychophysiological responses?" becomes instead, "To what extent and in what manner do emotions differ physiologically?"

The basic psychophysiological premise is well supported. As will be seen later, the common belief that there are different facial expressions for different emotions (as defined by self-report) has been empirically verified. In addition, the same facial expressions are characteristic for emotions (as defined by self-report) cross-culturally (Ekman, 1971, 1973; Ekman, Sorenson and Friesen, 1969). This cross-cultural evidence implies an innate biological characteristic. In addition, anger and embarrassment are often accompanied by blushing (caused by an increase in blood flow) while fear is often accompanied by paleness (caused by a decrease in blood flow).

Cannon, Mandler and Schachter are often cited as saying that cognition and not physiology differentiates emotion. Yet as mentioned above, the face changes with emotion. As many investigators have shown (e.g., Ax, 1953), different physiological responses do occur for different emotions. This research will be reviewed later. Therefore, Cannon, Mandler and Schachter can not be correct. The issue is no longer whether physiology does differentiate emotion. Data have shown that it does. The issue is rather in what manner and to what extent our present physiological measures can differentiate emotion.

One reason for the differences in theories as well as for the differences in experimental results has been methodological. "Emotion" is a term commonly used by the general populace to mean an affective state. The dictionary, defines emotion as, "...an affective state of consciousness in which joy, sorrow, fear, hate or the like, is experienced ... usually accompanied by certain physiological changes ..." (Random House Dictionary, 1973). The term is sometimes used with the intent of causal explanation ("He broke it because he was angry."). At other times it is intended as a descriptive term ("He broke it angrily," or "It is a happy occasion."). In both usages however, contrary to its observable instigating circumstances and manifestations, the "emotion" itself is a hypothetical construct. It is not concrete; it cannot be touched or completely defined. As hypothetical concepts, emotions can not be studied directly. Emotions must be inferred through observable instigators and manifestations. These observables will here be termed as emotion's indices. It is in the study of these indices that many of the methodological problems arise.

The indices by which emotion has been studied and inferred are numerous. As illustrated in Fig. 1., the most common observable indices have been emotional stimuli, expressive behavior, self-report and physiological indicators. The dotted circle represents emotion. One of the assumptions of this study is that each observable itself is only partially valid. Only by examining the intersection of all the circles can we gain a clearer view of the hypothetical process of emotion.

By using this Venn diagram, we can also gain a clearer view of the conceptual status of the total field. Most studies have looked at only some of the observables. Thus the results of these studies were necessarily limited in theoretical reach. One aim of this study was to help delineate the manner and extent of the convergence of the observables, beginning with the placement of major theoretical positions expressed or implied by various investigators into an overall conceptual framework. The framework follows that developed by Stoyva and Kamiya (1968) for describing the conceptual status of studies examining the physiological indicators of dreaming.

The circles labeled emotional stimuli (circle 2) and self-report (circle 4) have usually been included as parts of studies examining expressive behavior (circle 3) or physiological changes (circle 1). Problems involved with each of these will be discussed. The circle labeled expressive behavior has included studies in non-verbal communication of emotion through behaviors such as body language, or more specifically, hand movements and facial activity. While expressive behaviors have physiological components (e.g., muscle movement producing facial activity), most studies have not been concerned with measuring the underlying physiology. Instead these studies have been involved only with the visible changes. For this reason, in the present framework, expressive behavior and specifically facial activity, will mean visible changes in the face unless otherwise noted.

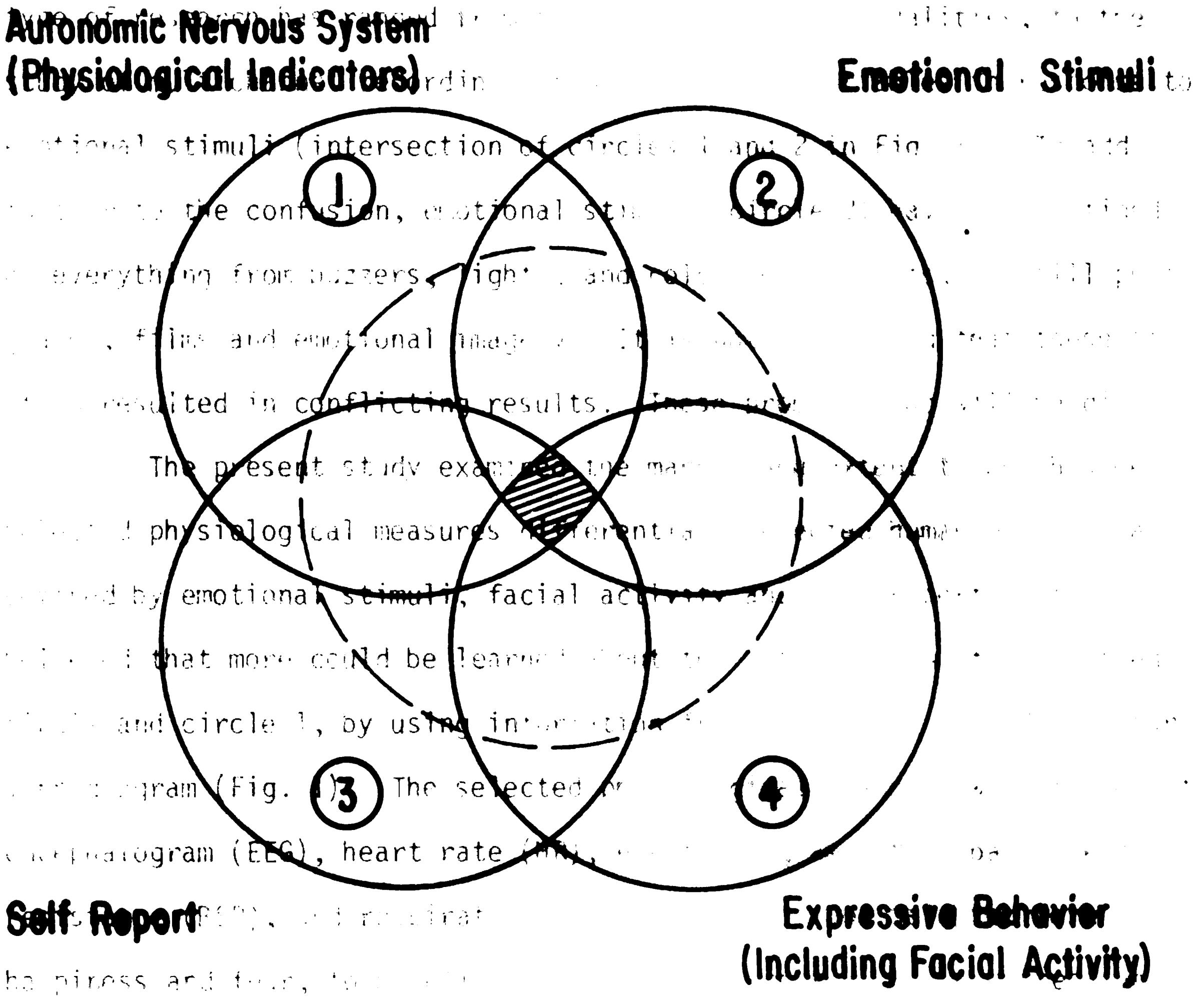
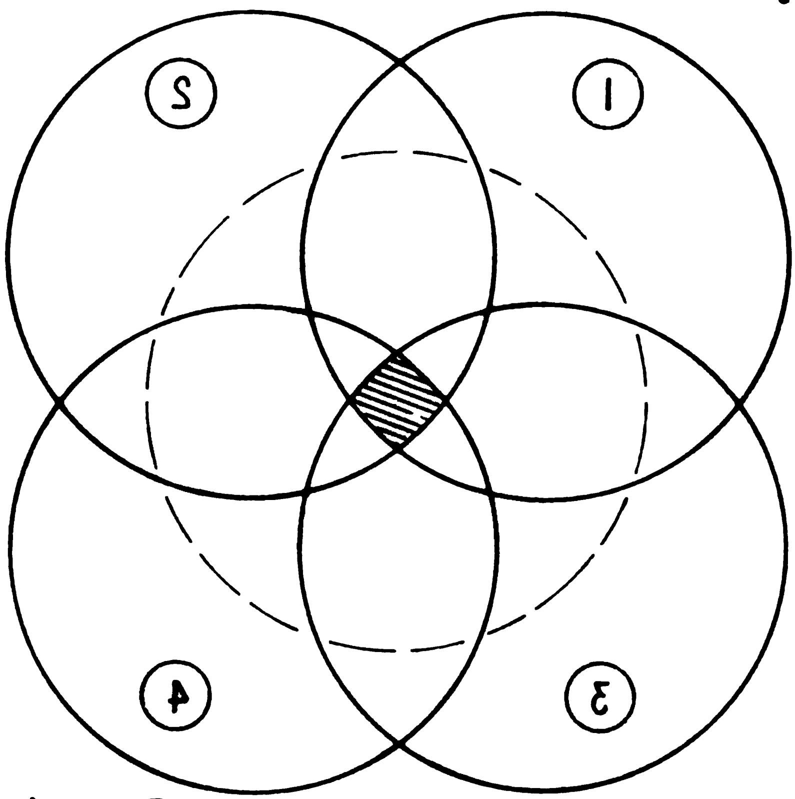


Fig.1 VENN DIAGRAM: EMOTION AND ITS INDICES

Emotional Stimuli

Autonomic Nervous System
(Physiological Indicators)



Expressive Behavior
(Including Facial Activity)

Self Report

Fig.1 VENN DIAGRAM: EMOTION AND ITS INDICES

Facial activity has been studied in great detail and will be reviewed later.

The circle labeled physiological indicators is still at an early stage of development. Research in the area of psychophysiology and emotion has yielded a confusing array of results. To add to the confusion, the type of research has ranged from the study of single modalities, to the study of multichannel recordings of physiological variables in response to emotional stimuli (intersection of circles 1 and 2 in Fig. 1). To add further to the confusion, emotional stimuli (circle 2) have been defined as everything from buzzers, lights, and cold pressor tests, to still photographs, films and emotional imagery. It is not surprising that these studies often resulted in conflicting results. These problems too will be discussed.

The present study examined the manner and extent to which some selected physiological measures differentiate selected human emotions as defined by emotional stimuli, facial activity and self-report. It was believed that more could be learned about the intersection of the dotted circle and circle 1, by using information from circles 2, 3, and 4 in our Venn diagram (Fig. 1). The selected physiological measures were the electroencephalogram (EEG), heart rate (HR), electromyogram (EMG), basal skin resistance (BSR), and respiration. The human emotions selected were happiness and fear, to be elicited by films (circle 2). The expressive behavior (circle 3) used was facial responses. Introspective self-report data (circle 4) were also collected. However, after the facial activity had been analyzed, it became clear that the film used for the elicitation of fear had elicited either the facial expressions of disgust or of a disgust/fear/pain/sad/anger blend. Therefore, the physiological responses to negative affect rather than to disgust were studied. For this reason, the question of interest became, _ex post facto_, the extent to which the selected physiological measures differentiate the positive emotions from the negative emotions.

By way of introduction, previous thinking and empirical work in the areas of facial activity and emotion (circle 3) and psychophysiology and emotion (circle 1) will first be reviewed and evaluated. A presentation of this study will follow.

I. HISTORY

The history of the conflict between the theory of general arousal and that of physiological differentiation is well known and will only be reviewed briefly.

The James-Lange theory (1884, 1885, 1922) was one of the first to propose that emotion was the result of the perception (psychological experience) of physiological bodily changes brought about by a stimulus. In short, emotion was the result of feedback from the physiological changes in the body. "...We feel sorry because we cry, angry because we strike, afraid because we tremble." (James, 1922, p. 101). James was interested in internal experiential (introspective) effects of emotional sequences. He was not interested in emotional behavior itself.

James' introspection and feedback hypothesis came right on the heels of another feedback theory. A few years earlier, Darwin (1872) had proposed that the brain received feedback from facial activity. Emotion, then, was the result of feedback from the facial expressions, rather than feedback from the physiological changes in the rest of the body. Although James had also included striate muscle feedback in his theory, this aspect was ignored by later researchers. They focused instead on the visceral aspect of James' theory.

The James-Lange theory came under scrutiny by some other researchers. Cannon (1927) disagreed with the James-Lange theory. Cannon believed that emotional experience was not the result of feedback from physiological responses occuring during an emotion inducing situation. He believed that emotion was independently aroused by thalamic processes. Incoming impulses from the emotional stimuli were filtered through the thalamus, where the distinctive quality of the emotional experience was added. The impulses then went to both the cortex, where the intellectual aspects were triggered, and to the viscera and musculature. Cannon felt that emotional experience and emotional behavior were different. The feedback from the autonomic nervous system (ANS) was not the major component. Cannon was instead offering a general arousal theory of emotion, which, in denying the importance of peripheral autonomic activity, gave birth to that school of thought still supported by Mandler and Schachter.

Cannon's monograph however, rather than being the last work on the topic, was the beginning of a research field still in existence today. Different neurophysiological and psychophysiological theories of emotion arose. A multitude of research studies examining the physiological components of emotion were done. Those of direct relevance will now be reviewed.

II. EMOTION AND THE FACE

The relevant theories and studies on emotion and the face will be presented, since the present study in part stemmed from this work.

Emotion and the face were given careful attention by Darwin (1872). In his book, Expression of the Emotion in Man and Animal, Darwin described each emotion and the evolution of its corresponding facial patterns. Darwin believed that there were a limited number of universal, biological emotions which had corresponding facial and postural muscle activities.

Darwin not only observed the facial expressions of different people (including children, the blind and the mentally retarded), but he related these facial expressions to whatever knowledge on anatomy was then available. Using anatomical work that Duchenne had published in 1862, Darwin studied and described the facial muscle actions necessary for the facial expressions.

Until recently Darwin's theory on the universality of facial expressions was ignored by psychologists studying emotion. It is only in the last twenty years that man's face has begun once again to play an important role in the study of emotion. Allport (1924) and Jacobson (1938) were two of the first researchers to suggest or "re-suggest" that the somatic system and the face may well play a major role in emotions. They both supported a theory that stated that facial as well as postural muscular feedback determined which discrete emotion was experienced.

Another theorist, Arnold (1960), agreed with the physiological aspects of the theory. Arnold however also added a cognitive component. As will be seen later, Laird (1974) and Schachter et al., (1962a, 1962b) also include cognition as an important component of emotion.

Arnold's theory did not support Darwin's idea that facial feedback determined emotion. However it did include the face as an integral component of emotion. Another neurophysiological theory of emotion that includes the face as an integral component of the emotional pathway was that of Gellhorn (1960, 1964).

Gellhorn's conclusions are that proprioceptive discharges in general, and cutaneous discharges in the facial area in specific, are necessary (although not sufficient) to determine all emotions. This theory is in total agreement with that of Darwin's and with the theories of Tomkins (1962, 1963) and Izard (1971, 1977). Tomkins and Izard both believe that feedback from the face underlies all emotion.

One of the major influences for the rebirth of the study of the face and emotions, in fact came from Silvan Tomkins. In his two volume book, Affect, Imagery and Consciousness (1962, 1963), Tomkins elaborates on his theory of emotion, in which the face plays a major role. A summary of this theory will be given.

Tomkins believes that the primary motivational system is the affective one. This theory is contrary to most psychological theories which state that drives are the primary source of motivation. Tomkins believes that drives are secondary, are amplified by the affect system, and, only then have any impact. The affect system is capable of masking or inhibiting the drive system. It is also capable of being activated independently of it. Affects are less clear than drives as it is harder to identify what or where in the organism they are. But the primary site of affects is the face. Therefore, feedback from the facial muscles is critical for the experience of emotion.

Tomkins distinguishes eight primary affects and describes their corresponding facial expressions (see Table I).

Izard (1971, 1977), in a re-statement of Tomkin's theory, also sees emotion as the primary motivational system with each emotion leading to different inner experiences. The principle assumption is that there are discrete positive and negative emotions. In addition, these emotions are different from one another. Each emotion is seen as a combination of three components. The three components are: neurophysiological (neural activity); neuromuscular (striate muscle or facial/postural activity); and phenomenological aspects (subjective experience). Note that these correspond to circles 1, 2, and 3 in Fig. 1. If any one component is incomplete, the result is a gross or vague emotion. Feedback from the facial expression is necessary, in combination with the three inter-related components, for a discrete emotion to occur.

Table 1

Tomkins Eight Primary Affects and their Corresponding

Facial Expressions

Positive

1) Interest-Excitement: eyebrows down, track, look, listen
2) Enjoyment-Joy: smile, lips widened up and out

Resetting

3) Surprise-Startle: eyebrows up, eye blink

Negative

4) Distress-Anguish: cry, arched eyebrow, mouth down, tears, rhythmic sobbing
5) Fear-Terror: eyes frozen open, pale, cold, sweaty, facial trembling, with hair erect
6) Shame-Humiliation: eyes down, head down
7) Contempt-Disgust: sneer, upper lip up
8) Anger-Rage: frown, clenched jaw, red face

(from Tomkins (1962), chapter 10, p. 337)

The theory of facial activity and emotion is also lent support by Plutchik (1962, 1966). Plutchik sees emotion as having adaptive significance that can be identified at all phylogenetic levels. He believes that for each primary emotion and emotion mixture, there is a discrete physiological and overt expressive pattern. Emotion is a patterned bodily reaction corresponding to the underlying biological processes common to all living animals.

Plutchik's theory is also in accord with Jacobson (1938). Both theories included the face as part of a larger bodily response which also included other skeletal muscles.

There are empirical data to support the theories of facial activity and emotion. Laird (1974) conducted two studies. A total of 77 subjects were asked to contract and relax certain facial muscles while being shown slides of pleasant and unpleasant nature. The subjects did not know they were producing "smiles" and "frowns." The effect of the facial activity on the quality of the corresponding emotional experience was evaluated. Although the differences between the experimental and control groups were small, the results indicated that the experimental subjects indeed reported feeling happier when their facial activity was that of a smile and felt angrier when facial activity was that of a frown. Laird sees this as supporting the hypotheses of Gellhorn, Tomkins and Izard. He concludes from his data that manipulation of facial activity is sufficient to produce changes in the quality of emotional behavior. In summary, Laird states that expressive behavior plays as important a role in emotion as does the level of physiological arousal and cognitive expectations.

While there are problems with Laird's methodology (such as demand characteristics, length of time subjects had to hold their manipulated facial activity, artifical situations, etc.), the data do lend support to the idea of a connection between facial activity and emotion.

Another emotion theorist and researcher, Ekman, has concentrated on the face and has made important contributions to the field of emotion and the face. With his co-workers, Ekman has studied facial activity cross-culturally (1969, 1971, 1973) and in relation to emotion (1972, 1976). Ekman and Friesen have developed a coding system for scoring facial activity (1969, 1971, 1975, 1976, 1978). The latter is of greatest relevance here.

Ekman, Malmstrom and Friesen (1971) were among the first investigators to realize that since emotion does change rapidly over time, it is difficult to study the physiological correlates. "Without precise locational criteria, one may lose the relevant physiological response, ... in the conglomerate of ongoing emotional behavior which often includes multiple affects as well as neutral or unemotional periods." (1971, p. 1). To overcome this problem, Ekman et al. correlated facial expressions to physiological changes. Since the present study is based on this one, Ekman et al.'s study will be described in some detail.

Twenty-five American subjects were video taped while watching a stressful film and a neutral film. Heart rate (HR) and galvanic skin response (GSR) were also recorded. Video tapes were later scored with the Facial Affect Scoring Technique (a precursor of the current Facial Action Coding System). In this way, the facial expressions were identified in time to the tenth of a second. The facial expressions were then descriptively classified on the basis on an *a priori* theory of which facial behaviors correspond to which affects.

Overall, mean HR and mean GSR during the films were not significant. However, when raw HR was examined in 1 sec intervals for the 5 seconds before and 5 seconds during a facial action, it yielded interesting results. For the facial activity labeled surprise, heart rate accelerated until the point that facial activity could first be seen (i.e., facial muscle firing) at which time it decreased. For the facial activity labeled disgust, HR began accelerating 2 seconds before the face fired and increased at a steeper rate at the point of firing. For periods of no facial activity, there were no changes. While there are problems with the design of this study, it was the first pilot data to "... suggest that the concomitant study of facial affective behavior and physiological changes holds promise as a means of gaining information about the interrelationships of two important behavioral systems." (Ekman, et al., 1971, p.5).

Another series of studies has been done on the relationship between facial affective behavior and physiological changes. These studies used emotional stimuli and expressive behavior to learn more about the physiological components of emotion. Buck and Miller (1974), Buck, Savin, Miller and Caul (1972), Jones (1935), Lanzetta and Kleck (1970), Oken, et al., (1962) and Prideaux (1922) all recorded GSR and/or heart rate in subjects undergoing some form of stress. Observers were later asked to identify the stress conditions by watching video tapes or still photographs of the subjects' faces. All six studies found a negative correlation between the intensity of the physiological response of the "sender" and the accuracy of his/her facial communication. They therefore concluded that the stronger the physiological response during affective stimuli, the less facial activity the subject will show. In addition, Buck et al., found that females were better senders of emotional cues.

Lanzetta and Kleck (1970) interpreted these data as suggesting that since people are punished when younger for displaying emotion, they try to inhibit their emotions. However, since internal states of arousal continue to be generated, the person feels a conflict which causes a larger physiological response even though the overt "emotion" is inhibited

These results are in contradiction with the other data presented which suggested that facial activity and physiology were integrated. Part of the problem lies in the different methodological procedures. Buck et al., (1972) and Lanzetta and Kleck (1970) used observers to draw inferences from videotapes. It is difficult to compare these results with others since one does not know what the subjects ("senders") behavior really was. One is not even sure if the behavior is affective behavior. The only clear point is that when the observers were forced to draw inferences about affect, they did so on the basis of what they saw. However, there are no data on the accuracy of the observer's inferences. While these results may therefore seem contradictory, they may in fact have been measuring different phenomena.

In addition, while Buck's subjects watched slides of different subject matter, Lanzetta and Kleck's subjects attempted to avoid electric shock. It is possible that Buck's slides were not sufficiently emotionally-laden while Lanzetta and Kleck's subjects were subjected to _stress_ (which can be interpreted as a series of unpleasant emotions) and not to be particular emotion _per se_.

More recently, Kleck et al., (1976), Lanzetta, Cartwright-Smith, and Kleck (1976), and Colby, Lanzetta and Kleck (1977) have performed a series of experiments whose results contradict their earlier findings. Instead the results lend support to the theory of a positive correlation between physiological indices of emotion and non-verbal displays of emotional affect. The studies sought to test the viability of the Tomkins-Izard-

Ekman theories vs. those of Jones-Buck-and the earlier Lanzetta and Kleck theory.

Subjects were instructed either to hide or to enhance their normal overt emotional facial responses in anticipation of an electric shock. (Note that once again shock was used as the stimulus for "emotion" whereas shock is more stressful than emotional.) Skin conductance was recorded and the subjects were asked to rate the aversiveness of the shock. This rating was termed the "subjective report" although it really rated the subject's feeling about the intensity of the shock and not his emotional feelings. In two experiments, video tapes and observers were again used, and as Lanzetta et al., (1976) say, "...changes in expressive behavior were not assessed directly but were inferred from a measure of decoding accuracy." (p. 361). The results indicated that enhanced emotional facial responses were accompanied by increases in skin conductance. Suppression of overt facial responses were accompanied by decreases in skin conductance responses. In addition, when the subjects were told that they were being observed, they showed less overt facial activity and again, less skin conductance responses.

In the Colby et al., (1977) study, subjects were instructed to pose three levels of "painful" facial activity to a constant shock. Results showed that skin conductance was directly proportional to the intensity of the facial expressions.

The final results therefore, indicated that modification of expressive behavior (i.e. inhibiting and enhancing facial activity) does affect the intensity of emotional responses. Inhibition of the facial expression results in skin conductance responses (SCR) that were significantly below baseline. Enhanced facial expressions resulted in

SCR's significantly above baseline.

These results are in complete opposition to Lanzetta and Kleck's earlier findings (1970). In the present series of studies, Lanzetta et al., state that their earlier results and proposed theory still hold true for changes in expressive behavior produced by "conditioned inhibition". The present study did not test for this. The present results however, help confirm the theory that there is a positive relationship between facial expressions, subjective reports and physiological indices of emotion (circles 1, 3 and 4 in Fig. 1).

In conclusion, the theories and data presented here strongly support Darwin's ideas that there is a correlation between facial activity and emotion. This implies that expressive behavior (circle 3) is indeed a good index of emotion. Therefore, facial response was one of the indices used in this study.

III. CURRENT RESEARCH ON THE PSYCHOPHYSIOLOGY OF EMOTION

A. Physiological Differentiation of Emotion

There are a multitude of psychophysiological studies of emotion. The goal of each was to answer one basic question. "One of the basic questions in the psychophysiology of emotion is whether different emotions show a characteristic physiological patterning." (Plutchik, 1966, p. 777). The early research on this question will now be reviewed.

As discussed earlier, the answers to this question fall into two schools of thought. The first believes that "... all types, qualities, and degrees of emotion probably can be described and measured through the functioning of physiological process..." (Ax, 1953, p. 197). They also believe that distinct emotions do have distinct physiological patterns associated with them. The second view is that the physiological component is one of general arousal for all emotions. Issues relevant to the first view will be reviewed first, followed by a discussion of data relevant to the second view.

The "physiological differentiation" view has been supported by Ax (1953, 1960, 1963, 1964), Averill (1969), Cohen, Goodenough, Witkin, Oltman, Gould and Shulman (1975), Funkenstein (1955, 1956), Geer (1966), Graham (1960, 1962), James (1884), Lacey et al., (1953, 1956, 1958, 1962, 1963, 1967, 1970), Lazarus (1962, 1967, 1975), Oken (1962), Schwartz (1975, 1976, 1977), Sternbach (1962), and Wilson (1967) among others. However, some of this data are still contradictory. This study was designed to further resolve the issues.

Lacey et al., (1953, 1956, 1958, 1962, 1963, 1967, 1970) were some of the first to examine response patterns. They hypothesized a principle of relative response stereotypy. GSR, HR, blood pressure and pulse pressure were recorded in a total of forty-two adult females and children who were undergoing cold pressor tests, mental arithmetic tasks and word fluency tests. The results led Lacey to believe that during environmental intake (i.e. subject attending to pleasant stimuli such as visual or auditory inputs including listening to emotionally laden tapes), HR decreased. During rejection of the environment (i.e. subject involved in unpleasant tasks such as mental arithmetic or cold pressor tests), the HR increased. Wenger (1950, 1951) later replicated Lacey's results in a total of 36 adult males.

The major criticism of Lacey's and Wenger's work is that their "emotional" stimuli were stressful. (Lacey himself called them noxious stimuli). At no point is mention made of what more specific emotions the subjects may have been experiencing. While it can be assumed that stress leads to unpleasant emotions, it is not know which of the unpleasant emotions are experienced, or how many are experienced. It is therefore impossible to draw conclusions about individual emotions.

One of the earliest studies however, that re-stimulated interest in the physiology of specific emotions was one by Ax (1953). Ax investigated a number of physiological variables during fear and anger (as defined by emotional stimuli and self-report). He believed that a close inspection might reveal a physiological difference between the two emotional states. Ax believed that recording from multiple sites adds to the understanding of the total emotional response and would help provide a qualitative description of emotional states. He raised three questions: a) Can subjects be classified in terms of their physiological reaction syndromes? b) Can physiological responses tell us which emotions are present? c) Are there patterns of physiological responses which may be diagnostic of emotional states (i.e. patterns rather than individual responses)? These questions are still important in research today.

To answer these questions, Ax monitored the electrocardiogram, ballistocardiogram, respiration, face and finger temperature, GSR, frontalis EMG and blood pressure. Subjects were told that the experiment was testing the physiological difference between normo- and hypertensives. Fear was induced by the experimenter gradually creating an atmosphere of alarm while wires sparked and an electric shock gradually increased in strength. Anger was elicited by an "incompetent" polygraph operator. The presence of emotion was determined by retrospective verbal self-reports as well as by spontaneous comments made during the experiment. Each condition lasted a minimum of five minutes with the total session lasting a minimum of 50 minutes.

The results indicated that increases in diastolic blood pressure, GSR, and average msucle tension and decreases in heart rate were significantly greater in anger. GSR decreases, respiration rate increases and muscle tension peak increases were significantly greater in fear. Correlation between the variables was low. This was interpreted as a marked uniqueness in the physiological expression of emotion.

The results of this study are encouraging for the view supporting physiological differences between emotions. The lack of correlation between the physiological responses, although less encouraging, could well be due to the gross time definitions of emotion.

The Ax study elicited emotions in a naturalistic way. More recently, stricter human subject protection committees have made it difficult if not impossible to replicate or conduct theses types of studies. Many researchers today rely instead of films to induce emotions. Lazarus, Speisman, Mordkoff, and Davison (1962) were some of the first to use film in this manner. They felt that films were natural and gave subjects an opportunity to identify with the characters.

Lazarus et al., (1962) used a film of subincision rites in aboriginal Australia and a neutral film about a corn farm. In addition to personality tests, they recorded heart rate and skin resistance, and collected urine samples. The results showed that mean GSR levels and mean heart rate were the best distinguishers between the stress inducing film and the neutral film. Note once again that "stress" and not emotion was assessed.

Sternback (1962) recorded skin resistance, gastric motility, respiration rate, heart rate, eye blink rate, and finger pulse volume in children watching the movie Bambi. The children were asked to identify which parts of the film they found to be sad, happy, funny or scary.

They were photographed (stills) through a one-way mirror. The data were then analyzed for those periods that had been rated saddest, happiest, etc. The only significant results occurred in increased skin resistance and decreased eye blinks during sadness and increased stomach motility during happiness. However, here too, each emotion was defined by a retrospective self-report for a gross time period.

Sternbach interpreted these data as patterns suggestive of inhibition of Sympathetic Nervous System (SNS) during sad and inhibition of Parasympathetic Nervous System (PNS) during happy. He also stated that an increase in Autonomic Nervous System (ANS) variables sampled would lead to a better picture of the total functioning of the Autonomic Nervous System (ANS) in different emotional states. In addition, Sternbach questioned the validity of relying on self-report. He stated that when there was a consensus of self-report then the use of a stimulus such as film, "...to elicit complex affective <u>and</u> autonomic responses becomes a potentially useful device for the study of more 'real-life' emotions..." (p.90).

Averill (1969) and Cohen et al., (1975) also used films to elicit emotion. Averill used a film of President Kennedy's assassination to elicit sadness, a control film, and a silent comedy to elicit mirth. He recorded blood pressure, heart rate, finger pulse volume, skin resistance, respiration, and face and finger temperature. The data were analyzed for the last six minutes of each film based on subjects ratings of the most emotionally arousing scenes. The results indicated that the sad group differed significantly from the mirth and control groups in increased systolic and diastolic blood pressure; the sad group and mirth group each differed significantly from the control group on increased GSR, but did not differ from each other; the mirth group significantly' differed from the sad group in increased heart rate.

Cohen et al., (1975) studied the effects of emotion on the respiration cycle. They showed two stressful films and two neutral films to male volunteers. Each film was shown during a separate session. The total number of breaths (i.e. rate) did not change. However, during the stress films, the expiration time significantly increased while pause time significantly decreased.

A third method of eliciting emotion that has often been used is that of imagery. Davidson and Schwartz (1976) found increased heart rate with imagined anger. Fair (1976), Fair and Schwartz (1976), Schwartz (1977) and Schwartz, Fair, Salt, Mandel and Klerman (1976a, 1976b) recorded facial EMG while subjects imagined happy, sad, angry and typical day scenes. The results showed the largest differences between happy and the other emotions, with corrugator muscle contration decreasing during happy. Schwartz et al., also found that there were patterns of responses for the different emotional images. Happy was accompanied by decreases in the area of the corrugator, increases in masseter and increases in depressor angularis. Anger was accompanied by increases in corrugator, masseter, depressor angularis and frontalis. In addition, Schwartz et al., (1976a) found that during the imagery of a typical day, normal subjects showed the happy EMG pattern while depressed subjects showed the sad EMG pattern.

An important question that arises here is one of different methods used to elicit emotion. Is the emotion experienced while watching a film (such as Lazarus, Averill, Sternbach and Cohen had their subjects do), the same as that experienced during imagery (such as Schwartz et al., had their subjects do), and is either the same as that felt during a 'real-life' situation (such as Ax's). Here again there is a problem in generalizing results across conditions or even comparing results from one condition to another. It is unknown whether the emotions are the same. It is also unknown whether the psychophysiological responses will be the same across all the conditions. No research has explored these questions which makes it difficult to make any comparisons across studies and makes it difficult to draw any conclusions.

B. The General Arousal Theory of Emotion

The second school of thought on the question of physiology and emotion believes that the physiological component of emotion is one of general arousal for all emotions (Cannon, 1915, 1927; Bindra, 1970; Engel, 1960; Mandler, 1975a, 1975b; Schachter et al., 1962a, 1962b). The two major proponents of this arousal theory of emotion are Mandler and Schachter.

Schachter and Singer's (1962a) and Schachter and Wheeler's (1962b) theory states that there is a general pattern of Sympathetic Nervous System (SNS) excitation associated with emotion. An emotional state is a function of both that physiological state and cognition appropriate to that state of arousal. They have concluded that given the same physiological arousal, the affective self-report will depend entirely on the cognition or social context to which a subject can attribute his feelings.

Plutchik and Ax (1967) criticized Schachter and Singer's experiment on several levels. These levels are: lack of double blind methodology, presence of different levels of arousal for the different conditions, inadequate self-report measurements, and "...marked over-generalization on the basis of very limited samplings of conditions, emotions, arousal states, and types of subjects." (p. 79). Another relevant criticism is whether arousal caused by an injection of a chemical substance (the Schachter procedure) is equivalent to the physiological arousal caused by naturally occurring stimuli.

In addition, Izard (1977) cites two recent but unpublished works by Maslach, and by Marshall, which failed to replicate Schachter and Singer's findings. Marshall used the same drug arousal method and found that subjects were not equally likely to report joy or anger. Maslach gave subjects hypnotic suggestions of autonomic arousal in order to create a set in which the subject would interpret negative feelings. Subjects responses again were independent of the actions of the confederate.

Mandler (1975) in discussing Schachter and Singer, suggested that since the same injection generated both anger and euphoria, this implied a general arousal theory and not a physiological pattern. Mandler agreed that the experience of emotion is an interaction of autonomic (ANS) arousal and cognitive interpretation. But he also stated that the arousal in emotions is non-specific. In his Theory of Arousal and Emotion, Mandler says that arousal provides the quality of the emotional state. Arousal however, may either be a response to a preprogrammed, automatic release of Autonomic Nervous System to an event, or it may be mediated by a "meaning analysis." "Meaning analysis" is an experience which changes what was once a neutral stimulus into a releaser of the Autonomic Nervous System. In either case, both the perception of arousal and the cognition for an emotion need to be present. Mandler's conclusion is that "...whether a particular input will lead to some emotional experience will depend on whether the arousal switch has been triggered, and whether the switch has been triggered depends on the meaning analysis that the input has undergone." (p. 79). However, Mandler never deals with the question of how arousal gets triggered. Schachter and Mandler each describe a process that short-circuits the system with an injection to stimulate arousal. They have no model that deals with how the arousal switch gets triggered or by what mechanisms it operates.

Mangler's theory is only partly in contention with those of the first school of thought. Most theoriests would not argue that emotion is characterized by its own specific pattern of responses which include physiological and cognitive components. In fact, Arnold (1969) and Laird (1974) include cognition in their theories. The disagreement arises from the type of physiological arousal involved. Mandler believes the autonomic nervous system response to emotion is undifferentiated.

IV. PROBLEMS WITH STUDIES OF PSYCHOPHYSIOLOGY AND EMOTION

The controversy of specific patterned responses vs. general arousal, and the lack of consistent results may be partially due to methodology. There are two major methodological problems with past studies.

The first problem involves the investigation of single physiological modalities. As Mandler (1975) so aptly stated, "...nothing as complex as emotional behavior and experience is likely to be determined by a single (italics mine) set of inputs or stimuli..." (p. 86). Along the same vein, nothing as complex as emotional behavior is likely to be determined by a single set of peripherally measured physiological variables. As shown by the work of Lacey et al., (1953, 1956, 1958, 1962, 1963, 1967, 1970) and Schwartz (1977), recording from multiple sites can not help but add to our understanding of emotional responses. Many parts of the human organism are interdependent. Together the different parts produce patterns of physiological responses that make up a significant component of both human behavior and subjective experiences (Wolf, 1970; Schwartz, 1977). Schwartz (1976) has suggested that patterns of responses can be an expecially sensitive way to learn more about how different physiological systems combine to produce different subjective experiences such as emotion. Though some studies have recorded from more than one site (Ax, 1953; Ekman, et al., 1971; Engel, 1960; Lacey, et al., 1958, 1962; Oken, 1962; Sternbach, 1971; Wenger, 1961), not one has looked at the pattern of responses or interactions between modalities. Instead, each variable was examined independently. This study did not look at the correlations between the physiological variables either, but, as a first step, did attempt to look at the directions of group responses.

One of the reasons for the neglect of response patterning is the Law of Initial Values (Hord, Johnson, and Lubin, 1964; Johnson, Hord and Lubin, 1963; Sternbach, 1966). Autonomic responses occur in such a way that changes in one measure are dependent on the levels prevailing before the emotion is elicited. Another reason for the neglect is response specificity. From their own research, Lacey et al., (1956, 1958) have developed four principles of response specificity. These are:

1. Relative Response Specificity - For different stress stimuli, a subject will tend to respond with the same hierarchy of activation;
2. Intra-stressor Stereotypy of Response - A single stressful stimulus will elicit reproducible patterns of response;
3. Inter-stressor Stereotypy of Response - Different stressful stimuli will elicit reproducible patterns of response;
4. Situational Stereotypy of Response - Changes in stimuli will produce changes in average response patterns.

Stereotypy makes it difficult to study one variable, much less several. There are however methods available to overcome some of these problems.

The second methodological problem is perhaps even more serious. The problem is the use of retrospective subjective reports to determine which emotions had been present. The physiological data are then averaged and analyzed over gross time periods. Yet the actual duration of emotions is unknown. In addition it is difficult to determine when one emotion has changed into another (Greenblatt, 1963). Emotions can often change very rapidly over time. In a short time period there can be a conglomerate of ongoing emotional behavior including different emotions, blends of emotions, and neutral (unemotional) periods (Ekman, et al., 1971). The data of the past therefore, may often have been confounded by these mixed emotions. The retrospective self-report may really have been an average of many emotions. Investigators thought they were studying anger or fear, yet by analyzing the data over long time periods, they may well have been studying a whole multitude of emotions. (This criticism holds true for "stressful" situations as well.) Tomkins (1962), when discussing a study he had once done using electric shock to elicit fear, stated,

> ...One had only to listen to the spontaneous exclamations throughout an experimental series to become aware of the difficulty of evoking one and only one affect by the use of what seems an appropriate stimulus. (p. 113)

He continues later on,

> ...This is not to say that the experimental investigation of affects is hopelessly complex, but rather that the investigator must proceed with unusual caution and imagination if he is to catch fleeting affect on the wing (p. 199).

This leads to an interesting question. What is the best way to measure emotion in the most discrete fashion? In the past, the two most frequently used techniques of measurement have been judge-ratings and retrospective self-reports. In the first, a blind observer judges the "senders" face and rates it as to which emotion and how much emotion is present. In addition to the problems already discussed, this method also raises the questions: a) can observers make accurate judgments of facial behavior? b) are some observers better than others? and c) are some subjects more accurately judged than others? (Ekman, 1971). Without clear-cut answers to these questions, it becomes difficult to interpret results. The second method, retrospective self-report, has its problems, as just discussed above. In addition, self-report may reflect the subjects wishes and beliefs as much as their real introspective feelings. One way to avoid this would be to get self-reports on a second-by-second basis. This procedure would however interrupt the flow of the natural sequence of events constituting emotional responding.

Another way to get more discrete information is to record facial EMG (Fair and Schwartz, 1976). It is possible to record the facial muscle tension and correlate that with the affects reported and with other physiological parameters. However, there are also problems with this method. The first problem is that visual observation of facial expressions would be difficult. The electrodes themselves may pull on the skin during a facial movement and thus act as a negative reinforcement for facial activity as well as inhibiting any natural overt facial expressions. Further, to get sufficient information one would have to cover the face with a multitude of electrodes, thus blocking inspection of the facial activity.

A second problem with this method is that the use of surface electrodes does not permit exact localization of the active muscle since they integrate the electrical activity in muscles in broad areas surrounding each electrode. (With additional research, the use of many small electrodes for detecting localized facial EMG to study emotion may be a very reliable method, especially in describing the muscle activity that occurs prior to visible facial activity.)

It is clear that there is a necessity for being able to look at changes over time during the presentation of the eliciting stimuli. As seen, this can be done by self-report (Fig. 1, circle 4), collected in a variety of ways, or by over-all judge ratings of emotions. However, a new less obtrusive procedure is now available. It has been designed to "catch fleeting affect" by identifying emotion in time (Ekman and Friesen, 1976, 1977, 1978). As it has long been recognized that emotional states are associated with non-verbal facial expression (Darwin, 1872; Ekman, 1973; Ekman et al., 1972, 1975; Izard, 1971, 1977; Tomkins, 1962, 1963; etc.), this new system, the Facial Action Coding System, or FACS, utilizes the face to help identify emotion (Fig. 1, circle 3).

FACS is an anatomically based descriptive system developed by Ekman and Friesen (1976, 1977, 1978). It is used for scoring visible movements of the face. It can be used in scoring either still photographs, film or video recordings.

FACS is strictly used to describe facial activity. It does not infer what the facial activity means. One observes the appearance and movement of the face and infers which muscles have fired to produce that change in appearance. The resulting score, or code, is a record of the facial activity. For example, FACS would descirbe an action unit which pulls the lip corners down rather than a "sad face." Each movement or measurement is called an action unit or AU. A series of AU's when combined, can account for any observed facial activity. Rules are given describing the minimal movement (minimal requirements) needed in order to score an AU as well as descriptions of appearance changes. Some AU's are also scored in intensity. Scoring is done on a descriptive level only; the interpretation as to what emotion or blend of emotions are being expressed is not done by the person doing the descriptive coding. The interpreter therefore, does not look at the overall gestalt of a face, but rather looks at a series of scores.

In summary, there is a sufficient amount of data to indicate that different emotions (as defined by the eliciting stimuli and/or retrospective self-report) do have different physiological responses, especially in the cardiovascular system (HR and respiration) and in skin response. However, due to poor measuring techniques such as retrospective self-report and gross time measures, it is not entirely clear to what extent physiological responses correspond to emotions. The facial activity is a good measure of emotion, and the Facial Action Coding System enables the researcher to use facial activity to examine corresponding physiological activity in small time epochs.

This study examined the physiological correlates of emotion by recording heart rate, basal skin resistance, respiration, and EMG. FACS was used to score facial activity. These physiological measures were chosen because the investigators reviewed above found them to be sensitive measures. The study was restricted to these variables due to the limitations of the equipment.

V. EEG, HEMISPHERIC LATERALIZATION AND EMOTION

Another approach to the study of the psychophysiology of emotion has been the examination of the electroencephalogram (EEG). Researchers have studied EEG patterns to further understand the role of brain mechanisms in emotion.

While most research has been done examining the EEG and anxiety, few studies have looked at the EEG and specific emotions. Those that have, have been involved with hemispheric specialization or dominance during affective stimuli.

Schwartz, Davidson and Maer (1975) used direction of eye gaze as a reflection of hemispheric activation. They found a longer mean number of left eye movements (i.e. right hemisphere activation) during emotionally laden questions than during non-emotional questions in right handed subjects. Davidson and Schwartz (1976) extended their findings in another study. EEG and heart rate were recorded. Heart rate was significantly higher during anger than during relaxation. There was however a major problem with this study. Only one affect, anger, was studied. (Relaxation is not an affect). It is therefore difficult to generalize or conclude that the physiological changes are due to the affect anger.

Another result was that self-generation of affective imagery was associated with significantly greater right hemisphere EEG activation that that of non-affective imagery. This result was much stronger in female subjects than in male subjects. Davidson and Schwartz concluded from these data that, as other researchers had suggested, the right hemisphere may be specialized for emotion. Davidson et al., (1976) then studied these sex differences in greater detail. They concluded that females show greater task-dependent assymmetry than males. In addition, there was significantly greater relative right-hemisphere activation during emotion only in females. DeWitt (1977) also found more right hemisphere activation (based on eye movement) during emotion in females. In addition, he found more left hemisphere activation in males. Drohocki (1974) and Erlichman and Wiener (1977) found more right hemisphere activation during positive affect than during negative affect. Harmen and Ray (1977) also found that during positive affect the left hemisphere sharply increased in power (i.e. left hemisphere showed increases in EEG alpha) and the right hemisphere showed more activation. During negative affect, the left hemisphere decreased in power.

Although hemispheric activation was determined by different techniques (eye gaze or EEG) and emotion elicited by different methods (imagery, cartoons, or emotional questions), the results all seem to indicate that the right hemisphere shows increased activation during emotions. This is especially true in female subjects.

Another way to study emotional effects on the hemispheres is to study lesioned patients. Arnold (1950) suggested that unilateral lesions in the thalamic regions produce marked affectivity on the damaged side of the body. A tumor affecting one side of the thalamus results in unilateral emotional expression.

Gainotti (1972) reviewed an Italian study done by Tezian and Ceccatta, who injected intracarotid amytal. Inactivity of the dominant hemisphere led to depression. Inactivity of the non-dominant hemisphere led to euphoric-mainical states. These results have been confirmed by Gordon and Bogen (1974), Rosadini and Rossi (1961) and Rossi and Rosadini (1967).

Heilman, Scholis and Watson (1975) studied right handed patients with either right or left hemisphere lesions. Patients with the right sided lesions were unable to score above chance on emotional questions. However, Schlanger, Schlanger and Gerstman (1976) were unable to replicate Heilman and found no differences between patients with right or left hemisphere damage.

In addition to studies of EEG assymmetry, two studies have been done examining the assymmetry of GSR. Myslobodsky and Rattok (1975) recorded the electrodermal activity (EDA) of both hands in right and left handed males. In all subjects, the EDA was higher in the right hand (i.e. left hemisphere) during verbal task. EDA was higher in the left hand (i.e. right hemisphere) during visual tasks. Greene (1978) found similar results. Skin conductance responses were larger in the left hand when stimuli were presented to the right visual field. While these studies did not deal directly with affective stimuli, they do support the notion that autonomic activity follows the same general rule as EEG activity in relation to hemispheric assymmetry. If the right hemisphere is the more emotional one, then it would follow that psychophysiological responses to emotional stimuli would be greater on the left side of the body.

Therefore, EMG and BSR were both recorded on the non-dominant (left) side of the body in the present study. EEG was recorded from both the right and left hemispheres to clarify which hemisphere is dominant for the different emotions elicited in this study.

VI. THE PRESENT STUDY

As noted, there is sufficient evidence to indicate that different emotions have different psychophysiological components.

The problem in the past has been determining the extent of psychophysiological differentiation in specific emotions.

Progress in this area may have been impeded by some past researchers accepting two assumptions. These two assumptions are: 1) a stimulus produces the same emotion for all subjects; 2) the emotion produced lasts for the entire time the stimulus is present. The past work has also suffered from an inability to focus on short time epochs of emotion. With the development of FACS, it is now possible to test the two assumptions stated above by obtaining objective, discrete periods of affective facial responses. With the aid of advanced computers it is also easier to time lock these facial responses to the psychophysiological variables.

The question addressed by this study was the extent to which the psychophysiological variables differentiated the positive emotions from the negative emotions. A multiple indexing system was used. The physiological (dependent) variables were basal skin resistance (BSR), heart rate (HR), EMG, EEG and respiration. The independent variables were film, facial responses and self-report. Emotion was defined in terms of: 1) film; 2) film and facial responses; 3) film and self-report; 4) film, facial responses and self-report.

CHAPTER 2

METHOD

Subjects: The experimental subjects were 36 right-handed Caucasian female volunteers ranging in age from 18-35 years (mean age = 25.14 years). One subject was eliminated from the study due to apparatus failure and procedural flaws, thus leaving a sample size of 35. As it has been shown that female subjects show more emotion on their faces (Buck, et al., 1972, 1974; Davidson, et al., 1976), only female subjects were used.

An attempt was made to restrict the sample to U.S. born females whose parents were also native Americans, since there are some cultural differences in emotion (Ekman, 1971). However, one subject was not born in the United States. Among the subjects' parents, three mothers and three fathers were from Europe, one father was from South America and one father was from the Middle East.

As a partial control for biological rhythms, all testing was done in the late afternoon or early evening, none of the subjects were taking birth control pills or any other medications, and all subjects were run within 6 to 11 days (mean = 7.8) after the start of their last menstrual cycle.

Subjects were recruited through advertisements. They were told that this was a psychophysiological study, that brain waves, heart rate, muscle tension, BSR and respiration would be recorded while they watched some films, and they would be paid $3.00 for their participation. No mention was made of the video equipment or of emotions. If the subject was right-handed and not taking birth control pills, she was asked to call back on the first day of her menstrual cycle. At that time, she was scheduled for a session as close to the seventh day of her cycle as possible.

Of the women who responded to the advertisements, the majority were right-handed and not on birth control pills. In addition, of those asked to call back, a majority did actually call back at the start of their menstrual cycle. The records for the exact figures are not available.

Apparatus: Four channels of EEG, a time signal, heart rate and thoracic and abdominal respiration were recorded on a Beckman Type R Dynograph. Trapezius and pectoralis EMG, basal skin resistance and another time signal were recorded on a Grass Model 78D polygraph.

EEG was recorded with Beckman A-C couplers (model 9806). The pre-amplifiers were set a 2 mV/cm. The power amplifiers were set at .02 resulting in a pen deflection of one cm for a 40 microvolt peak-to-peak signal.

A standard Beckman cardiotachometer (model 9857) recorded heart rate with a calibration signal of 60 and 120 beats per minute.

Respiration was recorded by means of two mercury strain gauges (manufactured by Park Electronics). One was attached across the thorax. The other was attached across the abdomen. Each gauge was 25 cm long and was attached at a stretched length of 30 cm. This stretch enabled the full range of respiration from minimum to maximum to be recorded without serious distortion from linearity. Output of the guage was proportional to changes in girth at the two sites.

Basal skin resistance was recorded from the Grass PGR setting of the input amplifier (model 7P1E).. A 10 microampere constant DC current was passed through silver/silver chloride electrodes with a diameter of 7 mm. Absolute value of skin resistance (BSR baseline) was recorded on magnetic tape for later analysis. GSR transients, reflecting changes in basal value, were recorded only on polygraph chart paper. The transients were not later analyzed. A calibration signal adequate to give a 2 cm pen deflection of the graphic record was used, with 1 mV input being equal to a resistance change of 10,000 ohms.

EMG was amplified using a Grass amplifier (model 7P511G). The half-amplitude points for the high and low frequency cut-offs were 30 Hz and 300 Hz respectively. The output of each EMG channel was full-wave rectified and sent to the polygraph paper as well as to the magnetic tape. A graphic record of the raw trace was also obtained.

All the polygraph data were also recorded on a Vetter tape recorder with dual plug-ins (model MX 712) set at 7½ ips with no flutter compensation. The thoracic respiration channel was recorded for all subjects. Due to equipment failure, abdominal respiration was available only for the last eight subjects.

Subjects' facial activity was video taped with a Panasonic video camera (model WV-200P black and white) equipped with a SONY TV zoom lens (f16-64mm; 1:2 set at f2). A SONY 3650 Video Tape Recorder (VTR) was used alternating with a Javlin VTR. The faces were monitored on a 9-inch video screen.

The films were shown with a Bolex SP80 projector in combination with a HPI caritel rear projection cabinet with a 14 inch screen. The pleasant film was three minutes long. It was produced by Ekman and Friesen and consisted of three parts: gorilla's playing in the zoo (scene 1), ocean waves (scene 2), and a puppy playing with flowers (scene 3). Scene two had been especially designed to produce self-reports of happy without producing facial activity corresponding to happy. Subjects previously viewing the pleasant film have described pleasant feelings (Ekman and Friesen, 1974). This film will be referred to as the pleasant film.

The unpleasant film was two minutes long. It was an edited version of a wood shop accident film in which one man has the tips of his fingers cut off (scene 1) and another man dies after a plank of wood is thrust through him by a circular saw (scence 2). This film has been rated as producing feelings of fear and disgust (Lazarus, 1966; Ellsworth, 1976). The original full-length version was first used by Birnbaum (1964). This film will be referred to as the unpleasant film. The order of film presentation was counter-balanced among the subjects.

Procedure: Each session began with the subjects: 1) signing a consent form (see Appendix A); 2) filling out the Zung Scale for Depression (Zung, 1965) (Appendix B); 3) filling out a general information sheet; 4) reading instructions on what would happen during the session and on how to rate the emotions they would be feeling (Ekman and Friesen, 1974) (Appendix C). The Zung Scale was used to screen out subjects with depression since Schwartz et al., (1976) found that depressed subjects showed facial activity that differed from normals. All subjects however, scored within the normal range on the Zung Scale. No further analysis was done with these data. At this point in the session, no mention was made of the video equipment.

The subject was seated in a comfortable, upright chair in a sound-deadened, electrically shielded chamber (7 feet by 7 feet, 4 inches), across from the hidden camera. The camera was hidden because there is anecdotal evidence to suggest that subjects act differently when they know they are being filmed.[1] Therefore, subjects were not told about the video equipment until after the session. Interviews taken at the end of the session indicated that none of the subjects had been aware that they were being monitored by camera.

EEG Grass electrodes were attached in a monopolar placing at C3, C4, O1 and O2 for subjects #1-9, and at C3, C4, T3 and T4 (Jasper, 1958) for the remainder, each referenced to the ipsilateral ear (A1 or A2). EEG placement was changed from occipital to temporal to reduce the eye movement artifact emanating from the ear reference. Two pairs of EMG Beckman electrodes were each placed 1½ inches apart at the left trapezius (Basmajian, 1977) and left pectoralis (Toomim, 1976). BSR silver/silver chloride electrodes were placed on the left (non-dominant) palm. Heart rate was derived from the wrist-to-wrist electrocardiographic signal. Thoracic and abdominal respiration were recorded with two mercury thread strain gauges. A ground was placed at the base of the neck. All electrodes had a resistance of less than 10k ohms.

After the electrodes were in place, the subject was seated two feet in front of the projection screen. Each subject was told that she had been randomly selected to be in a bright light condition. Two

---

[1] Since this study was done, Lanzetta et al., (1976) have reported data that support this theory.

light bulbs (200 watt bulb in back of the subject and 150 watt bulb in front and above) were turned on. These were needed to provide sufficient illumination for video taping the subjects.

The following instructions were then given:

> For the first ten minutes I'd like you to just sit quietly and relax. This will give me a chance to turn on my equipment and make sure I am getting good recordings. It will also give you a chance to get used to these surroundings a little bit. At the end of ten minutes, I will come on over the intercom and ask you to close your eyes for 5 minutes. This is a baseline period. At the end of the five minutes, I'll ask you to open your eyes for another 5 minute baseline. When that is over, I'll again come on over the intercom and ask you to fill out the first form (self-report form). Since at this point you have not yet seen a film, just respond to how you felt during the baseline periods. When you are done, tell me, and the first film will begin. When the film is over, fill out the corresponding forms and let me know when you are done.

After all questions were answered, the subject was told that she would be alone until she had finished filling out the emotion self-report forms at the end of the first film. After a ten minute rest period, five minute eyes-closed and eyes-opened baselines were recorded. The first film was then shown. Each film was at eye-level and the picture size was 8 inches by 12 inches. Fig. 2 shows how the experimental room was set up.

When the subject indicated she was done filling out the self-report forms, the films were changed. Another five minute eyes-opened baseline was recorded and the emotion self-report form filled out. The second film was then shown. There was a minimum of 10 minutes between the films. The films were turned on from outside the subject's room by remote control. When the second film was over, the subject again filled out the emotion self-report forms and indicated when she was

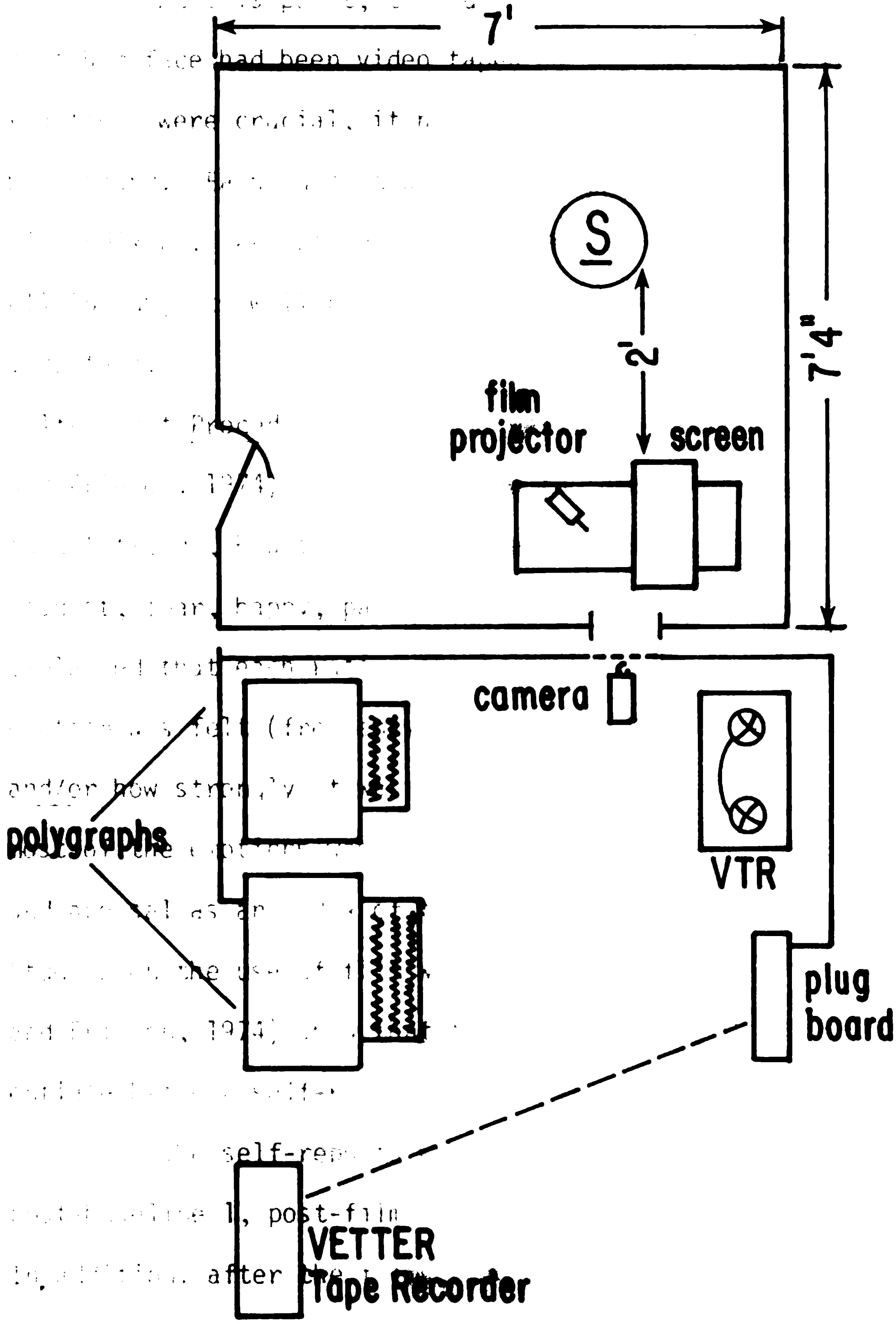


Fig. 2 EXPERIMENTAL ROOM

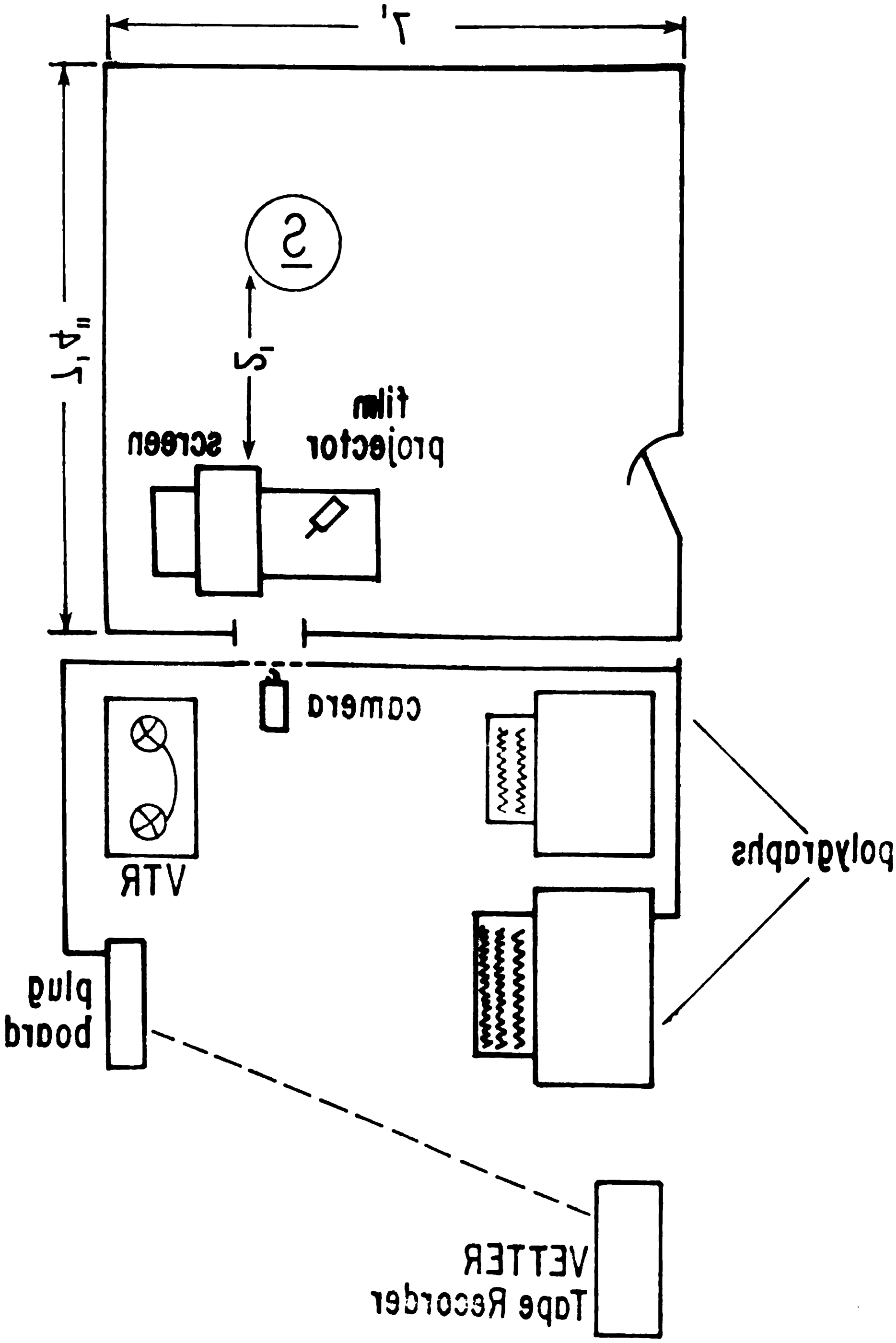


Fig.2 EXPERIMENTAL ROOM

done. (See section on self-report procedure.)

At this point, the subject was debriefed. It was explained that her face had been video taped during the films and since natural reactions were crucial, it had not been possible to inform her of this beforehand. Each subject was then asked to sign a second consent form (Appendix D). An option to erase the video tape was given. However all 35 subjects willingly gave *post hoc* permission for the use of the videotape.

Self-Report Procedure: Subjects were given self-report forms (Ekman and Friesen, 1974) that asked them to rate, on a scale from 0 (neutral) to 8 (strong), how they felt on each of the following: interest, anger, disgust, fear, happy, pain, sad, surprise, and arousal. It was explained that each rating should be based on the number of times the emotion was felt (frequency), the length of time it was felt (duration) *and/or* how strongly it was felt (intensity). While the definition of most of the emotions was clear, pain was described as empathetic pain and arousal as an index of the total emotional state (see Appendix C). Studies on the use of film with these emotion self-rating scales (Ekman and Friesen, 1974) show that the scales are sensitive enough to differentiate between self-reports of different emotions.

The self-reports were completed at four different intervals: post-baseline 1, post-film 1, post-baseline 2, and post-film 2. In addition, after the films, the subjects filled out a separate self-report form for each scene. Therefore, a total of seven forms were completed (2 baselines, 3 scenes in the pleasant film, and 2 scenes in the unpleasant film).

Coding Procedure: The facial activity of each subject was coded with the Facial Action Coding System (1976, 1978). This system was especially applicable since inter-coder reliabilities have been determined for six coders trained in this system (r=.756) and two of these coders were available for determining the reliability of the sample in the present study.

Coder 1 (the author) scored all the facial activity shown by the 35 subjects. Reliability was evaluated both for location and classification at two different stages in the study. Location meant when an action unit (AU) happened; the precise moment (video frame number representing 1/60 second) in which the action started and stopped. Classification was what happened; what are the AU's responsible for an observed change in facial behavior. The two questions are independent to some extent. Reliability could be high on classification, but low on location, or *visa versa* (Ekman and Friesen, 1978).

After the first 10 subjects had been scored, coder 1 randomly chose one of the two films for each of the subjects for coder 2 to score. Later in the study, a second sample was drawn, selecting a 30 second time period from the video records from each of the remaining 25 subjects. The second sample was only needed to verify the continuation of the high reliability. Therefore, since FACS is a time consuming system, the second sample was shorter than the first. Coder 2 scored this randomly selected sample. Appendix E presents the instructions given to the second coder.

Affect Assignment to Codes: A list of the facial activity scores (codes) was presented to two independent FACS experts (Drs. Paul Ekman and

Wallace Friesen, the developers of FACS). The list consisted of each set of scores that had appeared at least once. The experts were not told the duration of the facial activity, which film it had occurred in, or whether it had occurred more than once or by more than one subject. Each expert independently assigned an affect to each code and rated it as to how certain he was of that code representing that affect. These decisions were based on data from multiple sources including encoding and decoding studies of their own, research on facial muscle movements universal for emotions, and most of the movements labeled as emotional in chimpanzees and great apes (Chevalier-Skolnikoff, 1973; Ekman, Friesen and Ellsworth, 1972; Ekman, 1973; Ekman, Friesen, and Tomkins, 1971; Izard, 1971; Tomkins and McCarter, 1964). The two experts then combined their results and arbitrated any affect disagreements. Only those scores that represented positive affect or negative affect and that both experts were extremely certain about after arbitration, were then considered for analysis.

CHAPTER 3

RESULTS

The data analysis was designed to answer one question. This question was the extent of physiological differentiation between positive and negative emotions (as classified by film, facial responses and self-report). Different methodologies were used for answering this question.

Methodology used in many previous studies was based on two assumptions about emotion. The first assumption was that one stimulus produces the same emotion for all subjects. The second assumption was that the one emotion produced, lasts for the entire time that the stimulus is present. The methodologies used in this study were designed to test these two assumptions. This was done by examining whether different subjects experienced different emotions and whether these emotions only occurred at certain points within the film.

The stimuli used to elicite the emotions were a pleasant film and an unpleasant film. The responses measured were facial responses, self-report and physiological responses. The independent measures were the film, facial responses and self-report. The dependent measures were the physiological responses. Emotion was defined in four ways for purposes of examining the physiological differences between the emotions. These four ways were:

1. by film alone;
2. by film and facial response;
3. by film and self-report;
4. by film, facial responses and self-report.

Before the physiological data could be examined, it had to be determined whether the films were effective in producing the expected emotions and whether the facial responses and self-report results led to rejection of the two assumptions stated above (viz. a stimulus elicits the same emotion in all subjects and the emotion lasts for the entire time the stimulus is present). These data will be presented first, followed by the physiological data.

I. Facial Response Results

The facial activity coding yielded two results. The first result was that the pleasant and unpleasant film elicited different facial responses. The pleasant film elicited primarily positive facial responses. The unpleasant film elicited primarily negative facial responses. (Positive and negative facial responses are defined in Appendix F).

The second result was that within each film different subjects responded with different facial responses. The pleasant film elicited positive responses from some subjects and no responses from other subjects. The unpleasant film elicited negative facial blends (such as disgust/fear, fear/pain, etc.) in some subjects, positive facial responses in some subjects and no facial responses in the remaining subjects (see Table II).

In addition, different segments of the films elicited different responses from different subjects. Facial responses occurred most often at two different points (see Figs. 3 and 4).* For the pleasant film, the facial responses occurred during the first and third scenes. As mentioned in methods, the second scene had been pro-

*See Appendix F for explanation of legends.

TABLE II

Number of Subjects Responding Facially Within Each Film

Pleasant Film (3 min. long)

	Scene 1 (first min.)	Scene 2 (second min.)	Scene 3 (third min.)
Positive Facial Responses	19	2	23
No Facial Responses	16	33	12

Unpleasant Film (2 min. long)

	Scene 1 (first min.)	Scene 2 (second min.)
Negative Facial Responses	23	19
Positive Facial Responses	7	6
No Facial Responses	9	10

Fig. 3 OCCURRENCE AND DURATION OF FACIAL ACTIVITY IN THE PLEASANT FILM

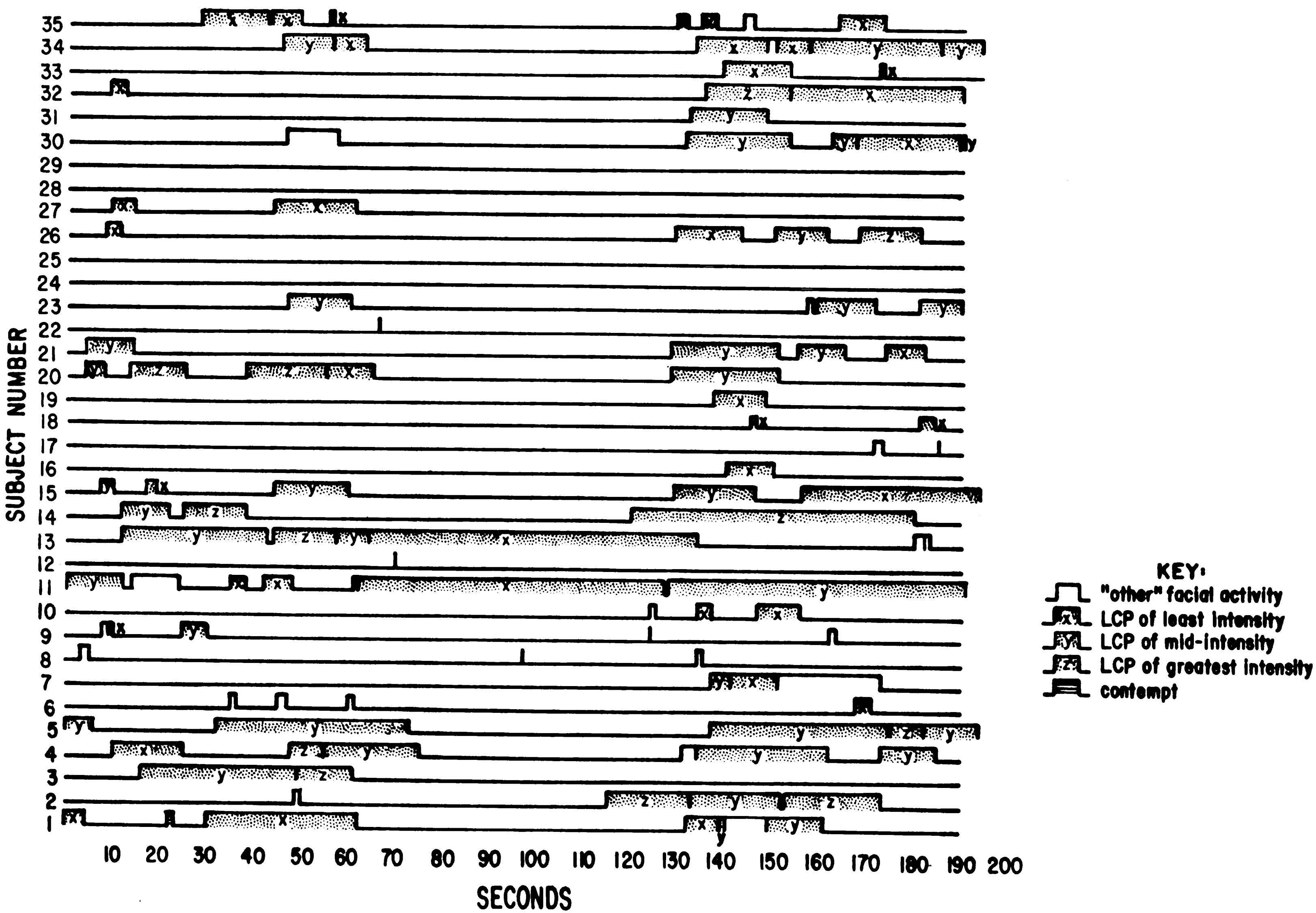
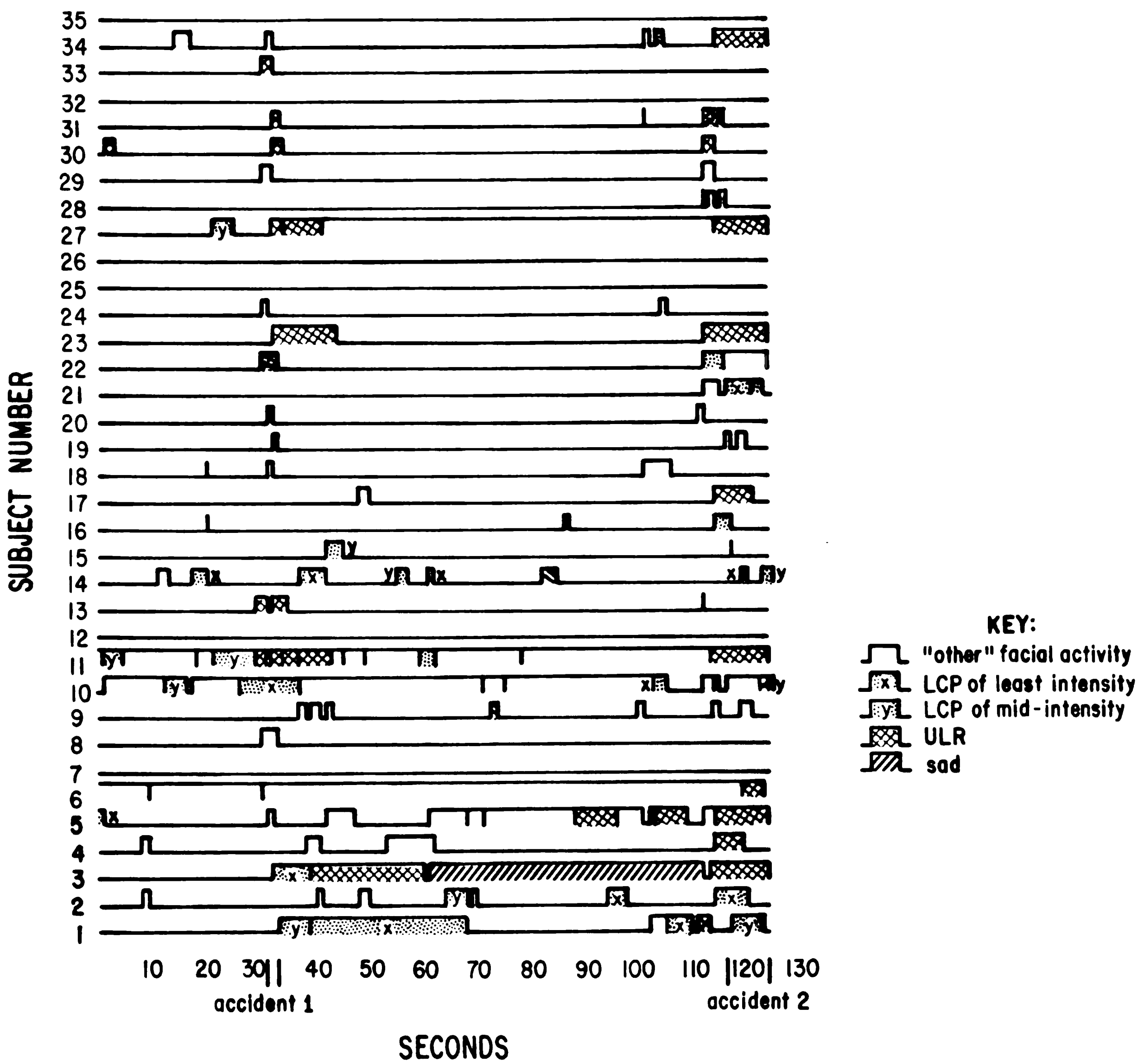


Fig. 4 OCCURRENCE AND DURATION OF FACIAL ACTIVITY IN THE UNPLEASANT FILM



duced to elicit positive self-report without eliciting positive facial responses. Therefore, it was not surprising that the second scene did not elicit facial responses. For the unpleasant film, the facial responses occurred primarily during the two accidents. Table II presents the number of subjects reacting with positive, negative or no facial responses for each scene in each film.

For purposes of counting types of facial responses, each scene in the pleasant film ended when the subject matter changed (i.e. monkey, ocean, puppy). Each scene was therefore, 1 minute long. In the unpleasant film, each scene was arbitrarily defined as 1 minute long to match the scenes in the pleasant film. In the unpleasant film, the negative and positive facial responses were not mutually exclusive.

In summary, the films did not elicit the same facial response in all subjects, nor did the facial responses last for the entire duration of the films as the two assumptions above suggested. Therefore the two assumptions can be rejected for facial responses. In addition, since the pleasant film elicited primarily positive facial responses and the unpleasant film elicited primarily negative facial responses, it can be concluded that the films were effective in eliciting different emotions as defined by facial responses.

Results of the facial activity coding reliability and facial activity classification reliability are presented in Appendix G.

II. Self-Report Results

The self-report data will now be examined to test the two assumptions. The self-report data yielded two results. The first result was that the pleasant film and unpleasant film each elicited different self-reports. The pleasant film elicited primarily positive self-reports. The unpleasant film elicited primarily negative self-reports.

The second result was that within each film, subjects responded with different self-reports. The pleasant film elicited high positive self-reports from some subjects and low positive self-reports from other subjects. A self-report was considered "high positive" when the positive affect (i.e. happy) was scored higher than each one of the negative affects. A self-report was considered "low positive" when the positive affect was not scored highest.

The unpleasant film elicited high negative self-reports from some subjects and low negative self-reports from other subjects. A self-report was considered "high negative" when one of the negative affects (i.e. disgust, fear, pain, sad, or anger) was scored higher than the positive affect. A self-report was considered "low negative" when the negative affects were not scored highest, (<u>i.e.</u> each negative affect was scored zero).

In addition, different scenes elicited different self-reports. Table III presents the number of subjects scoring each positive and negative affect as the highest in each scene. The affects of 'interest,' 'surprise,' and 'arousal' were also scored; however, they are not included in the tabulation. Interest, surprise and arousal were omitted because they themselves are not positive or negative, although they can be scored along with a positive and negative affect.

In summary, the films did not elicit the same self-reports from all subjects nor did the self-reports remain the same throughout

TABLE III

Number of Subjects Rating Each Affect as the Highest*

	Anger	Disgust	Fear	Pain	Sad	Happy	Nothing Scored
Pleasant Film							
Scene 1	0	0	0	0	2	29	4
Scene 2	0	0	4	0	0	25	6
Scene 3	3	2	0	2	1	27	3
Unpleasant Film							
Scene 1	3	13	15	17	5	0	2
Scene 2	3	10	18	17	4	0	2

*Note: When a tie occurred for highest rating, all self-reports with that rating were counted. For this reason the scores do not all add up to N=35.

the entire films. Therefore the two assumptions stated above can be rejected for self-report. In addition, since the pleasant film elicited primarily positive self-report and the unpleasant film elicited primarily negative self-report, it can be concluded that the films were effective in eliciting different emotions as defined by self-report.

The results of the baseline self-report data are presented in Appendix G.

III. Physiological Data Analysis

Once the two assumptions above had been rejected for facial responses and self-report, the physiological data needed to be tested. There were two hypotheses for the physiological data:

1. Is the same physiological response elicited for all subjects?
2. Do the physiological responses last for the whole time the films are on? To test these hypotheses, two data manipulations were performed. The first manipulation classified the subjects according to emotions. Emotions were defined in four different ways:

1. by film alone;
2. by film and facial response;
3. by film and self-report;
4. by film facial response and self-report.

The second manipulation averaged the physiological data over two different time segments:

1. for the length of each entire film;
2. for the 5 seconds prior to the facial response and for the first 5 seconds of the facial response.

Although the study originally started out with 35 subjects, due to intermittent equipment failures, the maximum number of subjects were 19 for heart rate, 12 for BSR, and 20 for respiration. When ever "all subjects" are referred to in this text, they refer to these N's of 19, 12 and 20.

The subject classification will be described first, followed by the description of the time segments.

Subject Classification: Film Alone

When film alone was used to classify the subjects, three comparisons of the physiological data were made: subjects watching the pleasant film vs. subjects watching the unpleasant film; subjects watching the pleasant film vs. the baseline; subjects watching the unpleasant film vs. the baseline (see Table IV, parts I-A and II-A).

Subject Classification: Film and Facial Response

When film and facial responses were used to classify the subjects, three comparisons of physiological data were made: in the pleasant film, positive facial responders vs. facial non-responders; in the unpleasant film, negative facial responders vs. non-negative and facial non-responders; in the unpleasant film, facial responders vs. facial non-responders. Facial responders included negative facial responders and any other facial responders (such as positive facial responders) (see Table IV, parts I-B and II-B). See Appendix F for a definition of positive and negative facial responses.

Subject Classification: Film and Self-Report

When film and self-report were used to classify the subjects, two comparisons of physiological data were made: in the pleasant film,

TABLE IV

Analyses

Physiological Data Time Segments	Subject Group	vs. Subject Group	Type of Analysis
I. Entrie Period (i.e. 3-min Pleasant Film, 2-min Unpleasant Film)	All subjects during pleasant film	All subjects Baseline	One-way ANOVA Repeated Measures
A. Film	All subjects during unpleasant film	All subjects Baseline	One-way ANOVA Repeated Measures
	All subjects pleasant film	All subjects Unpleasant film	One-way ANOVA Repeated Measures
B. Film and Facial Response	Pleasant film Positive Facial Responders	Pleasant film Facial non-Responders	One-way ANOVA
	Unpleasant film Negative Facial Responders	Unpleasant film Non-negative + Facial Non-responders	One-way ANOVA
	Unpleasant film Facial Responders	Unpleasant film Facial Non-responders	One-way ANOVA
C. Film and Self-Report	Pleasant film High positive self-report	Pleasant film Low positive self-report	One-way ANOVA
	Unpleasant Film High negative self-report	Unpleasant film Low negative self-report	One-way ANOVA
II. Five second Before Facial Response + Five second During Facial Response Periods	Pleasant film all subjects Before Facial Response	all subjects Baseline	One-way ANOVA Repeated Measures
A. Film	Pleasant film all subjects During Facial Response	all subjects Baseline	One-way ANOVA Repeated Measures

Table IV (con't)

Physiological Data Time Segments	Subject Group	vs. Subject Group	Type of Analysis
II. Five second Before Facial Response or Five second During Facial Response (con't) A. Film (con't)	Unpleasant film all subjects Before Facial Response	Baseline all subjects	One-way ANOVA Repeated Measures
	Unpleasant film all subjects During Facial Response	Baseline all subjects	One-way ANOVA Repeated Measures
	Pleasant film All subjects	Unpleasant film All Subjects	Two-way ANOVA Repeated Measures (film by Before-During)
B. Film and Facial Response	Pleasant film Positive Facial Window Responders	Pleasant film Facial Window Non-responders	Two-way ANOVA (facial response by Before-During
	Unpleasant film Negative Facial Window Responders*	Unpleasant film Facial Window Non-negative + Non-responders	Two-way ANOVA (Facial response by Before-During)
	Unpleasant film Facial Window Responders	Unpleasant film Facial Window Non-responders	Two-way ANOVA (facial response by Before-During
C. Film and Self-Report	Pleasant film High positive self-report	Pleasant film Low positive self-report	Two-way ANOVA (self-report by Before-During)
	Unpleasant film High negative self-report	Unpleasant film Low negative self-report	Two-way ANOVA (self-report by Before-During)
D. Film, Facial Response and self-report	Pleasant film Positive Facial Window Responder + High Positive self-report	Unpleasant film Negative Facial Window Responder + High Negative self-report	Two-way Repeated Measures ANOVA (Film by Before-During)

* See p.56 for explantion of facial window responders & non-responders.

subjects with high positive self-report vs. subjects with low positive self-report; in the unpleasant film, subjects with high negative self-report vs. subjects with low negative self-reports (see Table IV, parts I-C and II-C).

Subject Classification: Film, Facial Response and Self-Report

When film, facial responses and self-report were used to classify the subjects, one contrast was made. The contrast was the physiological data of subjects during the pleasant film vs. their physiological data during the unpleasant film. These subjects had positive facial responses and high positive self-report in the pleasant film and negative facial responses and high negative self-report in the unpleasant film. These were the same subjects and so a repeated measures design was used (see Table IV, part II-D).

These different subject contrasts were done to test the two hypotheses stated above. The subject contrasts are summarized in Table IV.

Time Segments:

The physiological data were averaged over two time segments. The first was based on the assumption that an emotion elicited by a stimulus would last as long as the stimulus was present. The following predictions could therefore be made: positive emotion (expressed physiologically) would be present during the entire three minute pleasant film; negative emotion (expressed physiologically) would be present during the entire two minute unpleasant film. To test these predictions, each subjects physiological responses were averaged for the three minutes of the pleasant film. Each subjects physiological responses were averaged for the two minutes of the unpleasant film (Table IV, part I). An analysis of the averaged three- and two minute physiological data should yield physiological differences if the positive and negative emotions were present for a substantial amount of the time the pleasant and unpleasant films were on.

The second time segment in which the physiological data were treated was based on Tomkins' (1962) idea that emotion was "fleeting." The data during the first 5 seconds of a facial response were averaged. The data were also averaged for the 5 seconds immediately preceding the facial response since little is known about the time course of physiological responses and facial responses (Table IV, part II). This treatment presented some problems however. There were no facial responses from which to choose 5 seconds for the group of subjects who were facial non-responders. If 5 second periods for each subject were randomly chosen for this group, it would be difficult to know if any statistical results would be due to differences between emotions or due to differences between different segments of the films. Therefore a ten-second window was chosen within each film. This segment represented the largest number of facial responses from the pool of all subjects.

Facial non-responders were those subjects who showed no facial response during the ten-second window. (This was true even if such subjects had shown facial responses at some other time during the film.) The first 5 seconds of the ten-second window became their "Before Facial Response" period. The last 5 seconds of the ten-second window became their "During Facial Response" period. These subjects were called facial window non-responders to distinguish this group of subjects from that group of subjects that never showed a facial response.

For the pleasant film, this ten-second window of facial responses (that is, the densest ten-second window) occurred during the last scene (puppy dog scene). For the unpleasant film the ten-second window of densest facial responses occurred during the second accident. For a subject to be classified as a facial responder (such as positive facial responder, negative facial responder, etc.), she had to have a facial response that overlapped with the ten-second window. This overlap had to be at least one second. The physiological data from the first five seconds of that facial response, whether they occurred during the ten-second window or not, were then averaged. This was called the During Facial Response period. The 5 seconds immediately preceding the start of the facial response was called the Before Facial Response period.

In summary, the different analyses were based on the different subjects comparisons and on the two time manipulations of the physiological data. The analyses are summarized in Table IV. In addition, the sample sizes for each analysis is listed separately for HR, BSR and respiration in Table V.

IV. <u>EEG Data</u>

The EEG analog tape recorded data were digitized on a PDP-15 computer at the rate of 64 samples per second, with a window of 1 second. The data were then broken down into six frequency bands via power spectral analysis: low theta (4-5Hz), high theta (6-7Hz), low alpha (8-10Hz), high alpha (11-13Hz), low beta (14-18Hz), and high beta (19-22Hz).

TABLE V

Sample Sizes for Analyses

	ENTIRE FILM			BEFORE-DURING Facial Response		
	HR	BSR	RESP	HR	BSR	RESP
All Subjects	19	12	20	19	12	20
Pleasant Film:						
Positive Facial Responders	15	10	17	11	8	14
Facial Non-responders	4	2	3	8	4	6
High Positive Self-report	11	8	14	12	8	15
Low Positive Self-report	8	4	6	7	4	5
Unpleasant Film:						
Negative Facial Responders	10	8	11	8	6	9
Non-negative + Facial Non-responders	9	4	9	11	6	11
Facial Responders	14	10	15	11	8	12
Facial non-Responders	5	2	5	8	4	8
High negative Self-report	16	11	18	16	11	18
Low negative self-report	3	1	2	3	1	2
Pleasant + Unpleasant Films:						
Positive Facial Responders + High self-report	--	--	--	4	3	7
Negative Facial Responders + High self-report	--	--	--	4	3	7

The total power (intensity) was divided by the band width (Hz) to give a measure of spectral intensity for each frequency band. EEG standardization was then done by using a data analysis program generated by Gevins et al. at the EEG Systems Group at Langley Porter Neuropsychiatric Institute.

Preliminary analyses revealed no significant differences among the data comparisons. Due to breakdown of the EEG equipment, many of the original records were contaminated with eye movement artifact. No further EEG analyses were computed. The mean scores for the EEG data presented in Appendix H.

V. Autonomic Physiological Data

The autonomic data were initially converted to digital data (A-D conversion) on a PDP-15 computer at the rate of 1 sample/second. This was done for visual and graphic examination only. Visual examination of the polygraph records and of the digitized EMG data showed no changes in either EMG channel during either of the films. Further analysis was therefore not necessary to confirm that there were no physiological differences between the emotions for EMG.

Heart rate (HR) and basal skin resistance (BSR) were redigitized on a PDP-7 computer at the rate of 5 samples/second. Respiration was hand scored to calculate the peak-to-peak amplitudes per breath.

The HR and BSR data were then standardized for each subject in relation to the mean and variability of her own baseline data. This standardization was done to eliminate unequal contributions from the different subjects to the total sample variance due to differences in intrinsic physiological lability. The formula used for standarization was $(x-\bar{x}_b / \sigma_b)\,10 + 50$, where x was the heart rate or BSR score for a subject,

$\bar{x}_b$ was her baseline mean and σ_b was her baseline standard deviation. The data from both baselines were combined in computing $\bar{x}_b$ and σ_b since the two baselines were not significantly different from each other. These standardized scores were used in the statistical analyses since they could readily be compared with the standardized baseline mean and standard deviation of 10 and 50 respectively. The variability of BSR and HR associated with each of the mean was not itself analyzed.

The thoracic (T) respiration and abdominal (A) respiration peak-to-peak amplitudes were hand measured since the abdominal channel was tape recorded only for the last eight subjects. An index, T-A/(T+A/2) was computed based on an index similar to that generally used to determine EEG hemispheric dominance. This index was more reliable than the straight T:A ratio since the latter would not be symmetrical about T+A. By dividing T-A by the mean of T+A, an adjustment was made for the different amplitudes of the breaths. Therefore, an index greater than zero meant T-dominance. A negative index meant A-dominance. An index equal to zero mean equal amplitudes of T and A.

The respiration index was standardized for each subject in relation to the mean and variability of her own baseline data. This was the same standardization procedure used for the HR and BSR data.

VI. Physiological Results

The results indicated that there were no significant differences when HR, BSR and respiration data were each averaged over the 3 minutes of the pleasant film and over the 2 minutes of the unpleasant film. This was true regardless of how the subjects were classified (Table IV, Part I-A, I-B, I-C).

Subject Classification: Film Alone and Five Second Time Segment (Table IV, Part II-A):

However, when the HR, BSR and respiration data were averaged over the 5 second Before Facial Response period and over the 5 second During Facial Response period, some significant results emerged. The mean scores were:

TABLE VI

Mean Scores for All Subjects

	Pleasant Film			Unpleasant Film		
	HR	BSR	RESP	HR	BSR	RESP
Baseline	50	50	50	50	50	50
Before Facial Response	53.6	51.5	55	51	54.2	54.5
During Facial Response	50.3	60.5	44.5	55	47.9	66.4
Sample Size (n)	19	12	20	19	12	20

Compare first the Before and During Facial Response periods with baseline means. The Before Facial Response HR mean ($\bar{X}$=53.6) was significantly higher than the baseline HR mean ($\bar{x}$=50) in the pleasant film (F=5.515;df=1/18;p=.03). However, the difference between the During Facial Response period HR mean and baseline HR mean in the pleasant film was not significant.

In the unpleasant film, there was also no significance in the difference between Before Facial Response period HR mean and baseline HR mean for all subjects. There was however, a significant difference between the During Facial Response period HR mean ($\bar{x}$=55) and baseline HR mean ($\bar{x}$=50) for all subjects in the unpleasant film (F=6.067;df=1/18;p=.02).

There were no significant BSR or respiration results for the above comparisons involving baseline means.

The results of the two-way analysis of variance of the Film x Before-During Facial Response for all subjects indicated significant interaction effects for HR, BSR and respiration. The interaction was significant at p=.004 for HR (F=11.023;df=1/18). The interaction was significant at p=.06 for BSR (F=4.498;df=1/9). The interaction was significant at p=.035 for respiration (F=5.136;df=1/19). These results are presented in Fig. 5 (HR), Fig. 6 (BSR), and Fig. 7 (respiration).

One-way analyses of variance were done comparing the Before Facial Response periods to the During Facial Response periods in each film to further examine the two-way interactions. In the pleasant film, the Before Facial Response period HR mean ($\bar{x}$=53.6) was almost significantly higher than the During Facial Response period HR mean ($\bar{x}$=50.3) (F=3.675; df=1/18;p=.07). In this same film, for BSR and respiration, although there were large mean differences the standard deviations were so large that there were no significant differences.

In the unpleasant film, the Before Facial Response period HR mean ($\bar{x}$=51) was significantly lower than the During Facial Response period HR mean ($\bar{x}$=55) (F=8.711;df=1/18;p=.008). In this same film, the Before Facial Response period BSR mean ($\bar{x}$=54.2) was significantly higher than the During Facial Response period mean ($\bar{x}$=47.9) (F=4.726;df=1/9; p=.05). The Before Facial Response period respiration mean ($\bar{x}$=54.5) was significantly less thoracically dominant than the During Facial Response period respiration mean ($\bar{x}$=66.4) (F=5.857;df=1/19;p=.02).

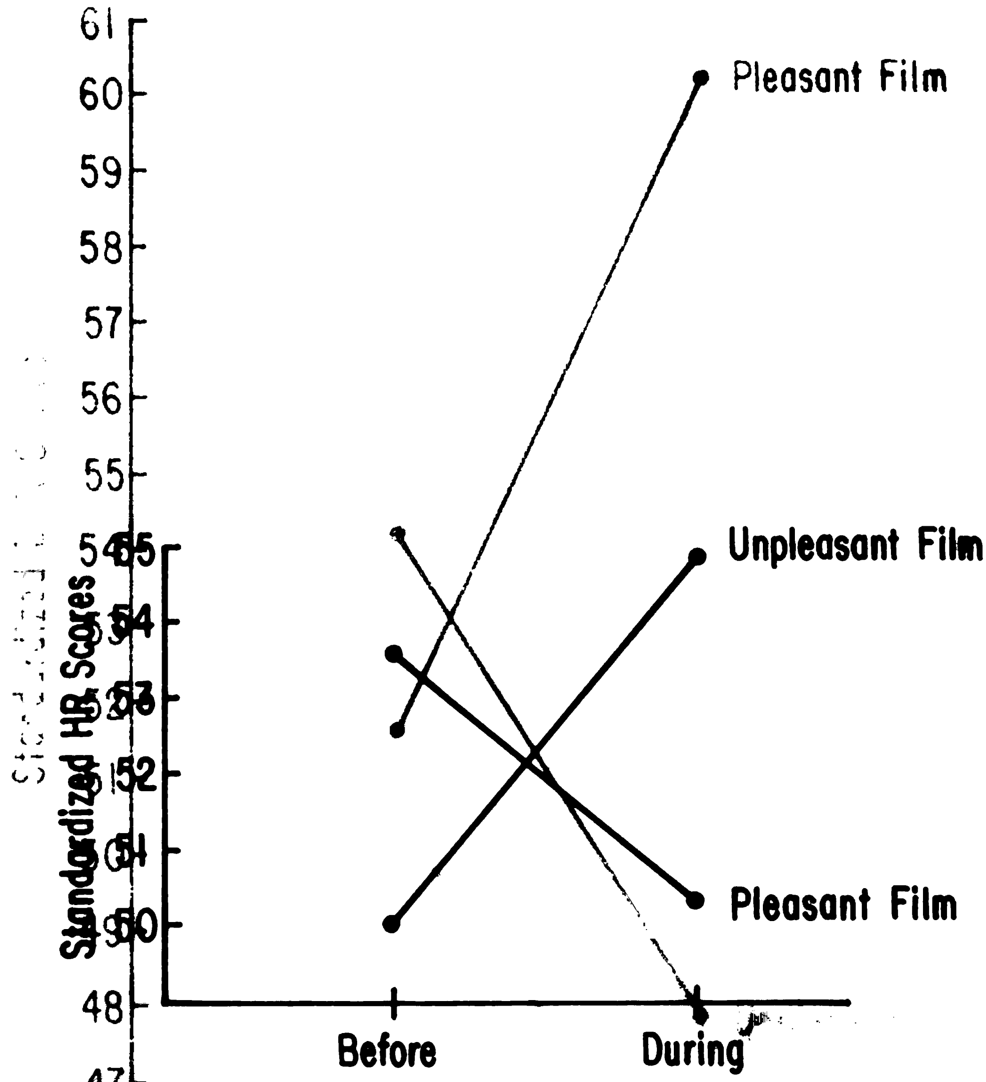


Fig 5 STANDARDIZED HEART RATE SCORES:
INTERACTION EFFECT (p=.004)
FILM x BEFORE – DURING FACIAL RESPONSE
FOR ALL SUBJECTS (n=19)

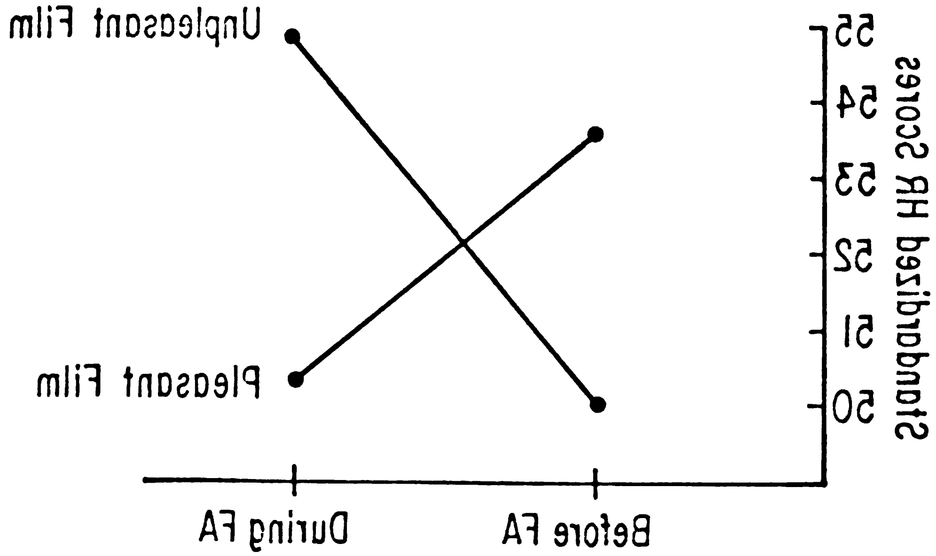


Fig. 5 STANDARDIZED HEART RATE SCORES: INTERACTION EFFECT (p=.004)
FILM x BEFORE–DURING FACIAL RESPONSE
FOR ALL SUBJECTS (n=19)

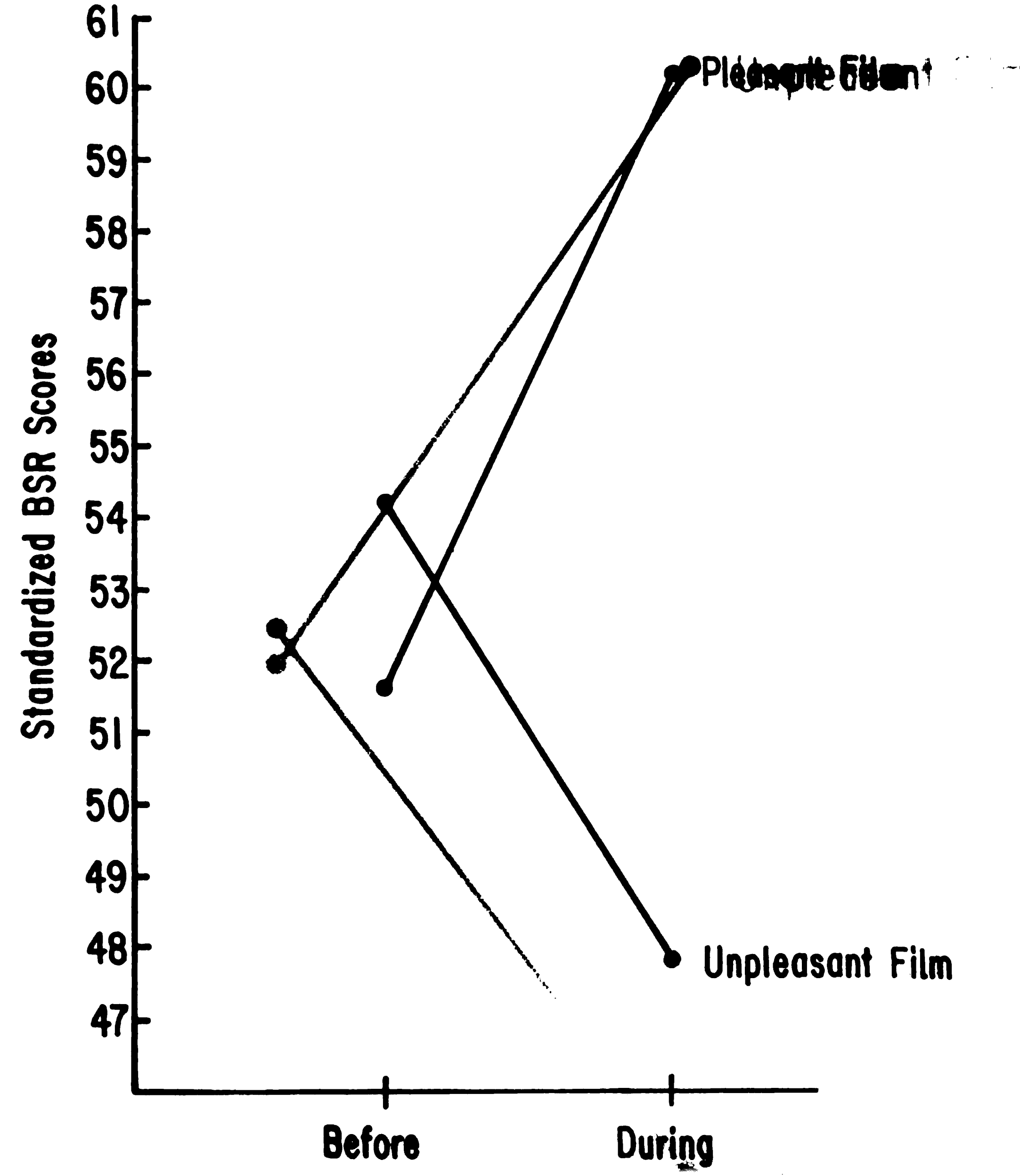


Fig.6 STANDARDIZED BSR SCORES:
INTERACTION EFFECT (p=.06)
FILM x BEFORE – DURING FACIAL RESPONSE
FOR ALL SUBJECTS (n=12)

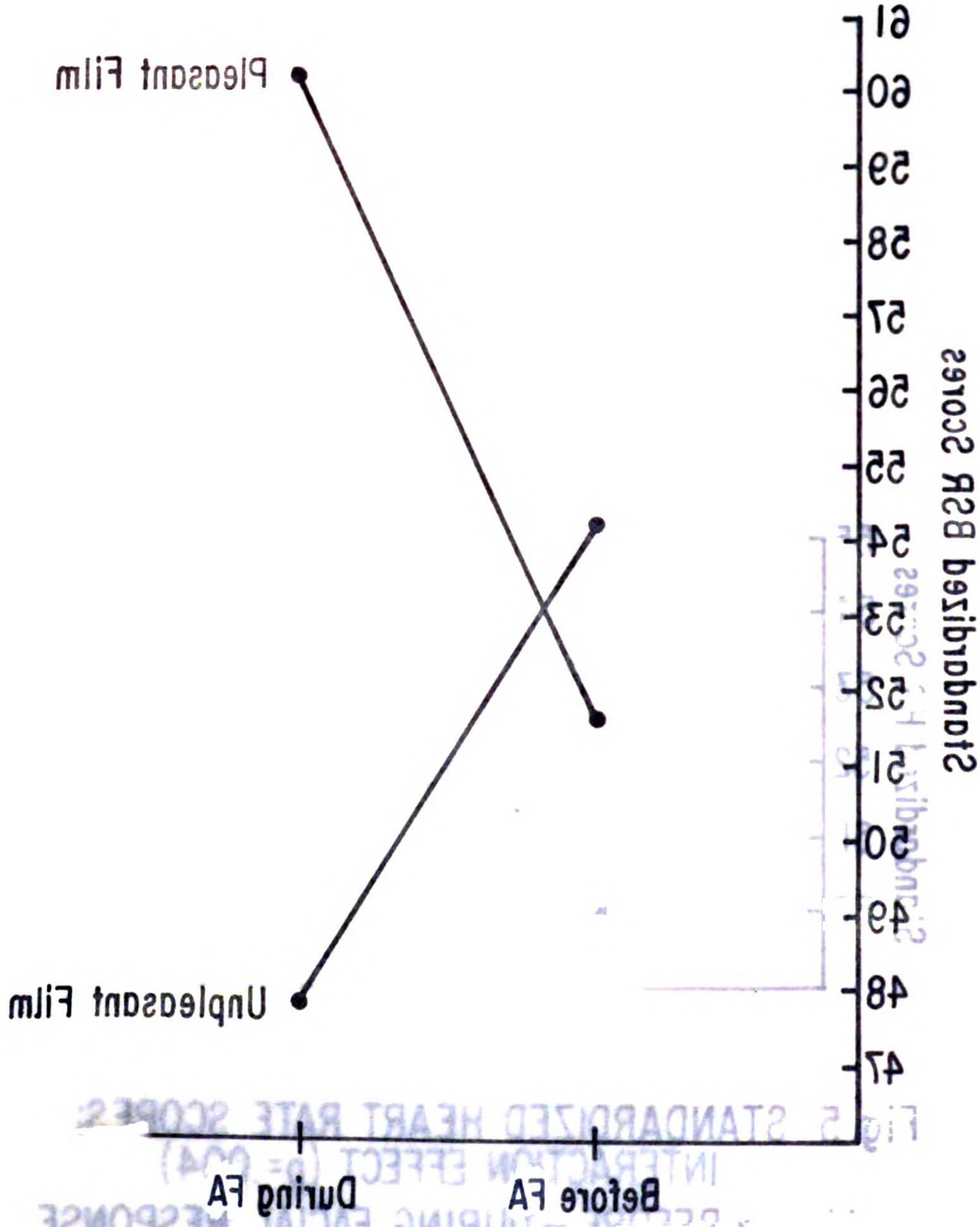


Fig.6 STANDARDIZED BSR SCORES:
INTERACTION EFFECT (p=.06)
FILM x BEFORE – DURING FACIAL RESPONSE
FOR ALL SUBJECTS (n=12)

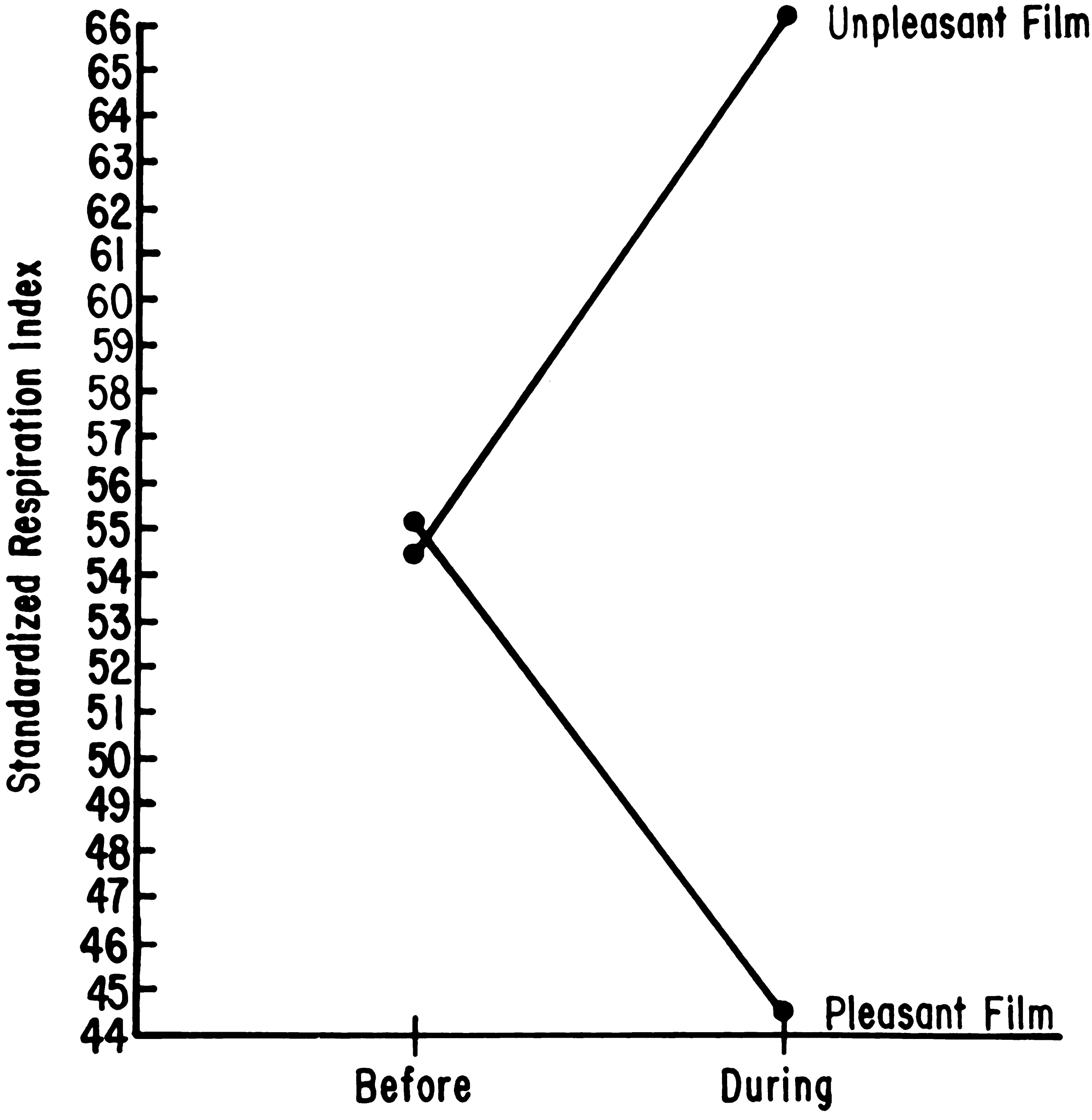


Fig. 7 STANDARDIZED RESPIRATION INDEX: INTERACTION EFFECT ($p=.035$) FILM x BEFORE–DURING FACIAL RESPONSE FOR ALL SUBJECTS ($n=20$)

Subject Classification: Film, and Facial Response, and Film and Self-Report - Five Second Time Segments (Table IV, Part II Band C)

In the unpleasant film, the Before-During Facial Response main effects were significant, regardless of how the subjects were grouped. That is, once the independent variable of densest facial responses was used to choose an area within each film, it no longer mattered how the subjects were classified. The following results were always significant:

1. For heart rate, the Before Facial Response period mean was less than the During Facial Response period mean;
2. For BSR, the Before Facial Response period mean was greater than the During Facial Response period mean;
3. For respiration, the Before Facial Response period mean was less than the During Facial Response period mean.

In addition in the unpleasant film, there were no significant differences in HR, BSR or respiration between the facial window responders and non-responders, between the facial window negative responders and the non-negative and facial window non-responders, or between the high negative self-reporters and the low negative self-reporters, except for the Before-During Facial Response main effect already mentioned.

In the pleasant film, there were also no significant differences in HR, BSR or respiration between the positive facial window responders and the facial window non-responders or between the high positive self-reporters and the low positive self-reporters.

Subject Classification: Film Facial Response and Self-Report - Five Second Time Segments (Table IV, Part II-D)

When the physiological data of subjects with positive facial responses and high positive self-reports in the pleasant film and negative facial responses and high negative self-reports in the unpleasant film were compared, there were no significant results for the standardized respiration index. However, when the same analysis was repeated for standardized thoracic scores and standardized abdominal scores (instead of the standardized index), there was a singificant film by Before-During (two way) interaction ($F=5.599; df=1/6; p=.05$). This was the same main effect seen above. The positive Before Facial Response mean ($\bar{x}=61.6$) was more thoracically dominant than the positive During Facial Response period mean ($\bar{x}=43.2$). On the other hand, the negative Before Facial Response period mean ($\bar{x}=45.5$) was less thoracically dominant than the negative During Facial Response period mean ($\bar{x}=63.9$). This interaction is shown in Fig. 8.

There were no significant HR or BSR results for this comparison.

In conclusion, when the facial responses were used as window indicators, there were significant physiological differences between the positive and negative affects. However when the facial responses and self-report were used to further classify subjects, there were no additional significant results.

Table VII summarizes all the significant results.

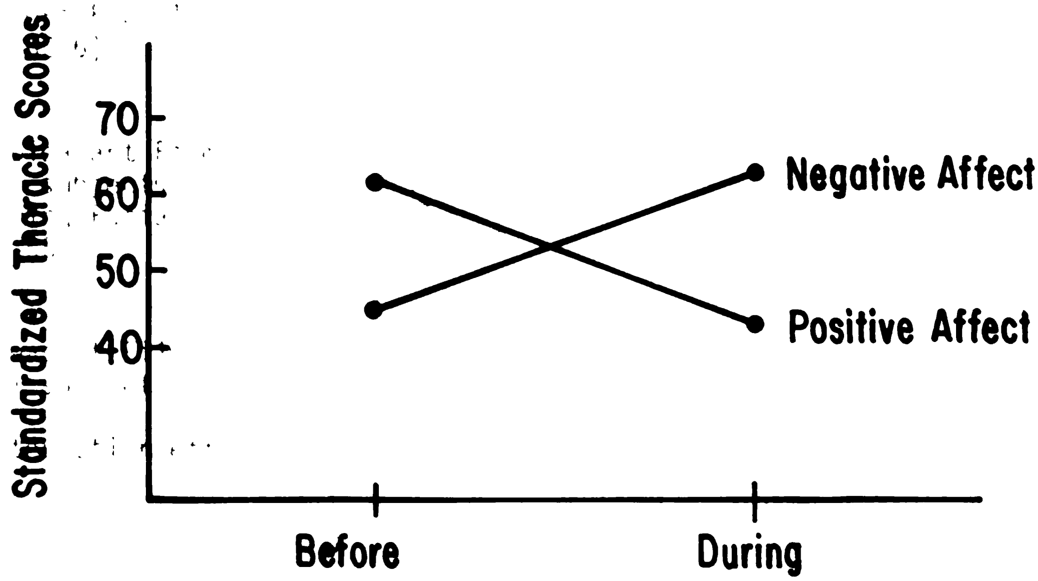


Fig.8 STANDARDIZED THORACIC SCORES
FOR POSITIVE AND NEGATIVE AFFECTS
BEFORE AND DURING FACIAL RESPONSE (p=.05)(n=7)

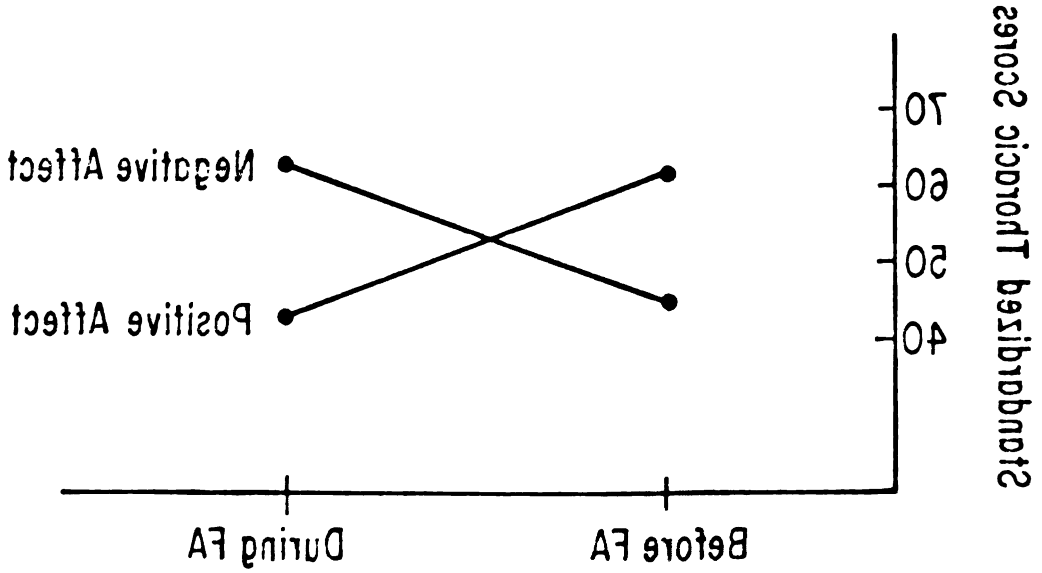


Fig.8 STANDARDIZED THORACIC SCORES
FOR POSITIVE AND NEGATIVE AFFECTS
BEFORE AND DURING FACIAL RESPONSE (p=.05)(n=7)

TABLE VII

Significant Results

1. Pleasant Film All subjects Before Facial Response ($\bar{x}$=53.6)	Baseline All subjects ($\bar{x}$=50)	HR	p=.03
2. Unpleasant Film All subjects During Facial Response ($\bar{x}$=55)	Baseline All subjects ($\bar{x}$=50)	HR	p=.02
3. Pleasant Film All subjects	Unpleasant Film All subjects		
Interaction effects found:		HR Film x Before- During	p=.004
		BSR Film x Before During	p=.06
		Respiration Film x Before During	p=.035
Further analysis showed:			
Unpleasant Film All subjects Before Facial Response	Unpleasant Film All subjects During Facial Response		
HR: $\bar{x}$=51	$\bar{x}$=55		p=.008
BSR: 54.2	47.9		p=.05
Respiration: 54.5	66.4		p=.02
4. Pleasant Film Positive Facial Responders + High Positive Self Reporters	Unpleasant Film Negative Facial Responders + High Negative Self Reporters		
Respiration (Film x Before-During interaction)			p=.05

CHAPTER 4

DISCUSSION

The major conclusions of this study contradict much of the previous research on the psychophysiological differentiation of emotion. One of the accepted views has been that of general physiological arousal responses to emotion. Our results indicate that the physiological responses to a positive emotional stimulus (pleasant film) are different from the physiological responses to a negative emotional stimulus (unpleasant film).

In addition, our methodology allowed us to show why some other studies found no physiological differentiation while our study did. Previous research assumed that all subjects would respond to a single stimulus with the same emotion. Our results indicated that the films did not elicit the same emotion (as measured by facial response and self-report) in all subjects. Previous research also presumed that the emotion elicited lasted for the entire duration of the stimulus. Our results indicated that the emotional responses did not last for the duration of the films.

When our data were analyzed in the same manner as the data of studies supporting the general arousal theory, we reproduced their findings. The physiological data were averaged over the 3 minute and 2 minute films. There were no significant physiological differences. However, when we utilized an independent variable to determine what emotion was present, when emotion was present and in which subjects the emotion was present, the analyses revealed findings not previously found.

In this study, the other independent variable used was facial response. The ten second window eliciting the most facial activity among all the subjects as a group was chosen. The physiological data for the 5 seconds immediately preceding the facial response and the first 5 seconds during the facial response were each compared to baseline and to each other for the different classifications of subjects. There were significant HR results for all subjects within each film when the 5 second periods were compared to baseline. There were significant HR, BSR, and respiration results for all subject comparisons within the unpleasant film when the 5 second periods were compared to each other.

The significant respiration results were as Darwin (1882), Tomkins (1963) and Plutchik (1962, 1966) would have predicted. Darwin wrote that the facial activity accompanying disgust had evolved from the act of eliminating something distasteful from the mouth, or from the act of avoiding the inhalation of a noxious smell (thus implying shallow breathing). Tomkins and Plutchik theorized that disgust was therefore a rejection of something. The negative affect in this study (as defined by film, and facial response) was primarily disgust with blends of fear, pain, sad, and/or anger. Therefore one would expect the disgust (i.e. rejection) to be accompanied by upper chest breathing. In fact, the Before-During Facial Response period significantly interacted with the Films (p=.03). In the unpleasant film, the During Facial Response period was significantly more thoracially dominant (i.e. upper chest breathing) than the Before Facial Response period. In the pleasant film, the During Facial Response period (i.e. positive facial responses) was more abdominally dominant than the Before Facial Response period. This result was true when subjects were categorized by film alone, film and facial response, film and self-report, and, film, facial response and self-report.

The significant heart rate results in the unpleasant film were as Lacey (1958) would have predicted. Lacey's theory states that with environmental rejection, one sees a heart rate increase, while with environmental intake, one sees a heart rate decrease. We have already determined that the negative affect in this study was equivalent to rejection based on Darwin (1882), Tomkins (1963) and Plutchik (1962, 1966), and based on the respiration results. When the heart rate data were analyzed, there was an interaction effect between Film and the Before-During Facial Response periods (p=.004). In the unpleasant film (i.e. environmental rejection) heart rate was in fact significantly higher in the During Facial Response period than in baseline (p=.02) or in the Before Facial Response period (p=.008).

In the pleasant film (environmental intake), the heart rate decreased from the Before- to the During Facial Response period (p=.07). It is important to note here that within the pleasant film the heart rate data significantly increased from baseline to the Before Facial Response period (p=.03). This result is not predicted by Lacey's hypothesis. It was an unexpected result and requires further study. The HR then decreased from the Before- to the During the Facial Response period. This decrease in the During Facial Response period may have been dependent on the increase in the Before Facial Response period. This result may have been due to an anticipation of the unknown. It is very difficult to interpret.

There were no significant results when the heart rate data of subjects with positive affect were compared to their data during negative affect (as defined by film, facial response and self-report). However, the heart rate data during the negative affect were higher than those during the positive affect. The lack of significance may have been due to the small sample size (n=4).

The heart rate increase seen during the negative affect also supports the results of Ekman et al., (1971). Ekman et al., found that unstandardized heart rate data decreased for the 3-5 seconds before the face showed the response of disgust, when the data were graphed and analyzed second-by-second. There was then a change in direction 2 seconds before the face visibly moved. This increase then continued for the next 5 seconds. When our unstandardized heart rate data for subjects showing facial disgust and self-reports of disgust higher than any other affect (n=7) were graphed in one second epochs, the results resembled those of Ekman et al., (see Fig. 9). However, when the standardized HR data were graphed in the same way, there was no decrease in heart rate prior to the facial response. There was however, still an increase in heart rate during the first 5 seconds of the facial response. Because this data was based on a small sample (n=7), the lack of a decrease in the standardized data may imply that the decrease seen in the unstandarized data was caused by one or two subjects showing significantly lower heart rates in that time period rather then having been caused by an emotional reaction.

When the basal skin resistance data were anlayzed for all subjects for the Before- and During Response periods, there was an interaction effect with Film (p=.06). BSR decreased from the Before-

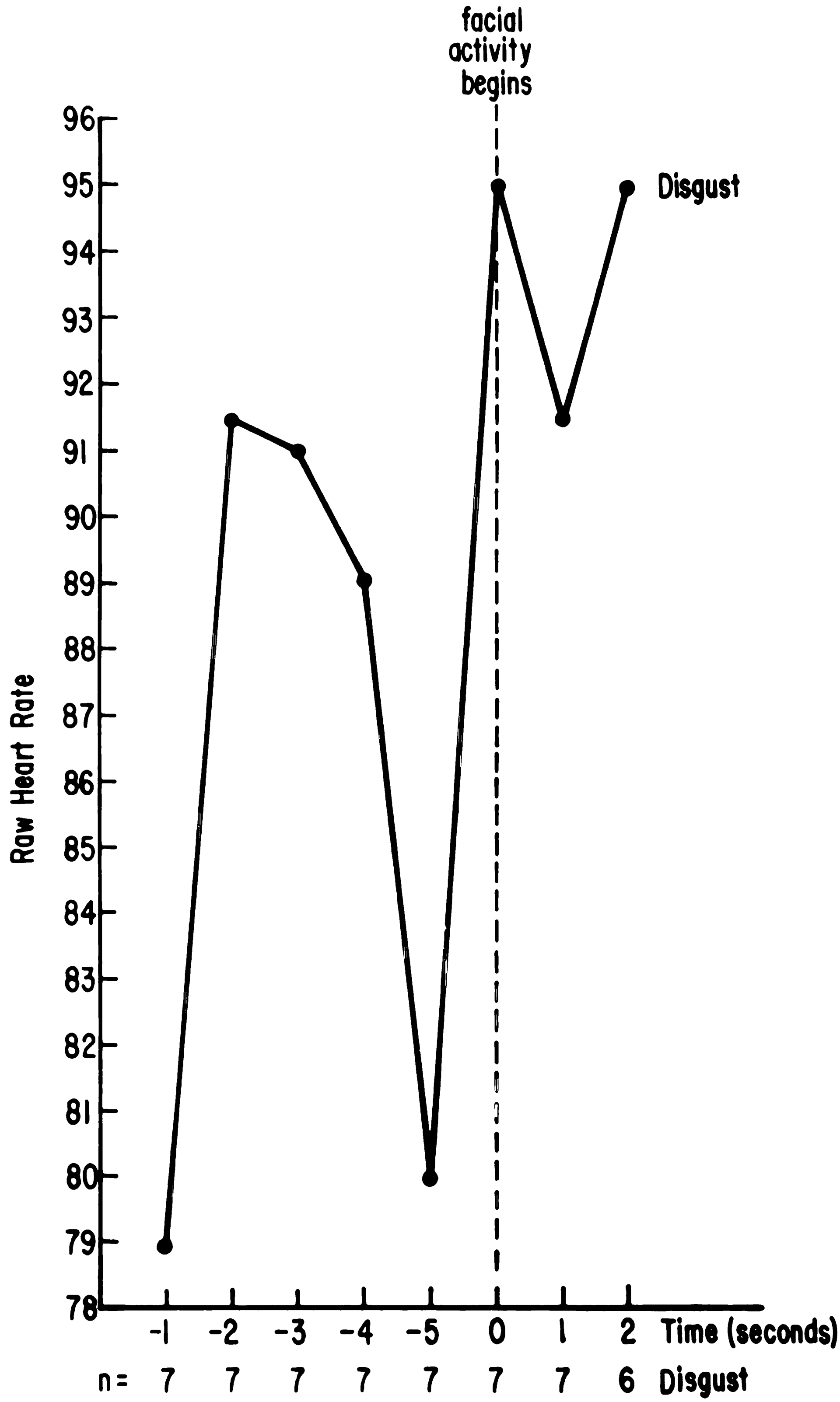


Fig. 9 SECOND BY SECOND RAW HEART BEAT SCORES
FOR 5-SECONDS BEFORE AND
3-SECONDS DURING FACIAL RESPONSE

to the During Facial Response period in the unpleasant film (p=.05) BSR increased from the Before- to the During Facial Response period in the pleasant film. These results are what one might expect to see since a decrease in resistance (i.e. increased sweat) is compatible with subjective reports that accompany negative feelings. At the same time, an increase in resistance (i.e. less sweat) is compatible with a relaxation response. While positive affect is not synonomous with relaxation, the two certainly are compatible responses.

The BSR data for subjects with positive and negative affect (as defined by film, facial response and self-report) were not significant. This may have been due to the small sample size (n=3).

It is important to note that for the within film comparison results, it no longer mattered whether or not the subjects showed a facial response once the time window of the densest facial responses was choosen. The facial responses were only necessary for choosing the time window. There were no significant physiological differences between the facial window responders and non-responders. This finding was unexpected. There may be multiple explanations for this surprising result. Some of these are:

1. The facial non-responders may have a higher threshold for overt facial responses although their threshold for Autonomic Nervous System responses was comparible to that of the facial responders. It is known that increased facial muscle tension can be recorded before any overt facial response is seen (Schwartz, et al., 1975; Fair, 1976). This leads to an interesting question. If one were to record the facial EMG of the facial non-responders, would they find that the non-responders too are responding facially but at a lower level than the overt facial responders?

If so, this might explain the lack of physiological differences between the facial responders and non-responders, i.e. both groups were in fact facial responders. Researchers interested in emotion need to look at autonomic responses along with facial muscle tension (EMG).

Related to this is the possibility that the facial non-responders are habitually monitoring and controlling their overt responses. This too could be measured with facial EMG.

2. A second possibility is that the facial non-responders were just less aroused than the facial responders. The facial non-responders in fact reported less arousal and less negative affect on their self-reports (Ekman, Friesen and Ancoli, in preparation). It may be that although they showed physiological responses in the same direction, the physiological responses were smaller than those of the facial responders. This was not examined in the present study.

3. A third possiblity is that by using the facial responses in a different way, different results may emerge. The densest window of facial responses could still have been used to choose a time segment for the facial non-responders. For the facial responders, however, the facial response with the greatest intensity, of the longest duration or of greatest frequency could have been chosen. These paradigms need to be explored.

4. A fourth possibility is that by looking for physiological differences between the negative responses (i.e. fear vs. disgust, disgust vs. pain, etc.), different results would have emerged. Ekman and Oster (1979) state that the face differentiates between positive and negative affect. This brings up three questions: 1) Can the positive and negative affects be further differentiated? 2) Is there physiological differenti-

ation between the positive affects; Is there physiological differentiation between the negative affects as Ax's (1953) earlier study suggested? 3) Do different social circumstances and different types of people affect the amount of physiological differentiation seen? Future research will have to answer these questions.

In summary, the overall conclusions of this study are:

1. Heart rate (p=.03) significantly increased from baseline to the Before Facial Response period in the pleasant film;
2. Heart rate (p=.02) significantly increased from baseline to the During Facial Response period in the unpleasant film;
3. Heart rate (p=.008) and thoracic respiration (p=.02) significantly increased from the Before- to the During Facial Response period in the unpleasant film;
4. Basal skin resistance significantly decreased from the Before- to the During Facial Response period in the unpleasant film (p=.05);

In addition, the two assumptions stated above can be rejected. That is, films do not produce the same emotion (as measured by facial response, self-report and physiological response) for all subjects. Also, the emotions that are elicited, do not last for the entire time the film is present; rather the responses are short term. An independent variable is needed to find these short time epochs. The area of densest facial responses seems to be a good independent measure to use.

Table VIII shows the direction of the physiological responses and the significance levels.

Some past studies may have failed to find these physiological results because most studies have used one independent variable such as film to measure emotion. When comparing physiological differences

Table VIII

Summary of Physiological Results

	DURING FACIAL RESPONSE	
	Pleasant Film	Unpleasant Film
Heart Rate	decreased (↓) NS	increased (↑) p=.008
Basal Skin Resistance	increased (↑) NS	decreased (↓) p=.05
Thoracic Respiration	decreased (↓) NS	increased (↑) p=.02

	During Positive Facial Response and High Positive Self-Report	During Negative Facial Response and High Negative Self-Report
Thoracic Respiration	decreased (↓)	increased (↑) p=.05

NS= not significant

between Before and During Facial Response periods within a film, facial responses were needed as independent measures for locating segments of greatest response within the film. Self-report was not necessary for these types of analyses.

It must be pointed out that the primary negative affect reported was not the same as the primary negative affect seen on the face. Although the face showed primarily disgust or disgust/fear/pain/sad blends, the self-reports showed greater intensity fear or pain than disgust (see Table II). Ekman (1971) found that when American and Japanese males watched films of other people suffering, the most common facial response was disgust, or fear/pain/sad blends or disgust/fear/pain/sad blends. Tomkins (1975) theorized on subjects' responses to others suffering. He stated that there were two possible responses: 1) empathy (i.e. with a fear/pain/sad blend) or 2) rejection and holding the other person responsible for their own suffering (i.e. with disgust or contempt). Ekman and Friesen (1979) found indirect support for these ideas in studying accounts of nurses who were asked about their reactions to patients' suffering. The data lead them to believe that people are less willing to admit that they are disgusted by suffering than they are willing to admit they are empathetic.

These data might account for the discrepancy between the facial responses and self-report. These data may also account for the lack of physiological differentiation when emotion was measured by film and self-report. Subjects are less likely to report how they truly feel; they try to make themselves look more caring and less rejecting.

Another problem with the self-report data was that it was collected retrospectively. It is difficult to know if the self-reports collected referred to the locations finally analyzed since the self-report was a retrospective one reported at the end of each film. In future studies, an attempt should be made to collect self-reports immediately as the emotion is experienced.

The overall results of this study are encouraging. However, there were some methodological problems with this study. The screen size was limited by the size of the experimental room and was only 14 inches square. In addition, in order to be able to video tape the subjects' faces, the room had to be very brightly lit. These problems may have diminished the results by diminishing the impact of the films.

In conclusion, based on our results, we can feel confident in supporting the position of physiological differentiation of emotion as expounded by Ax, Plutchik and Tomkins. We now know that small time epochs are necessary for studying physiological differentiation of emotion. A system such as the Facial Action Coding System can help locate these discrete time epochs. There also seems to be a convergence of the various indicators of emotion. Different emotions can be differentiated by use of these indicators. It should now be possible for future researchers to delve deeper and learn more about the extent of the physiological differentiation of emotion.

In 1956, Lacey said that, "... In facing the problems of patterned activation of the autonomic nervous system, we are at the very edge of knowledge." (p. 156). This study however now provides evidence that there are indeed psychophysiological response patterns of emotion.

REFERENCES

Allport, F.H. Social Psychology. Cambridge, Massachusetts: Houghton-Mifflin, 1924.

Arnold, M.B. An excitatory theory of emotion. In M.C. Reymart (Ed.). Feelings and Emotion. McGraw Hill, 1950, 11-33.

Arnold, M.B. Emotion and Personality. Vol. II Neurological and Physiological Aspects. New York: Columbia University Press, 1960.

Averill, J.R. Autonomic response patterns during sadness and mirth. Psychophysiology, 1969, 5, 399-414.

Ax, A. The physiological differentiation between fear and anger in humans. Psychosomatic Medicine, 1953, 15, 433-422.

Ax, A. Psychophysiology of fear and anger. Psychiatric Research Reports, 1960, 12, 167-175.

Ax, A. Autonomic responses and emotions: Further discussion. In P.H. Knapp (Ed.) Expression of the Emotion in Man. New York: International University Press, 1963, 197-199.

Ax, A. Goals and methods of psychophysiology. Psychophysiology, 1964, 1, 8-25.

Basmajian, J. personal communication, 1977.

Bindra, D. Emotion and behavior theory: Current research in historical perspective. In Physiological Correlates of Emotion. P. Black (Ed.), Academic Press, 1970, 3-20.

Birnbaum, R. Autonomic reaction to threat and confrontation conditions of psychological stress. Unpublished doctoral dissertation, University of California, Berkeley, 1964.

Boucher, J.D. and Ekman, P. Facial areas and emotional information. Journal of Communication, 1976, 25(2), 21-29.

Buck, R., Savin, V., Miller, R. and Caul, W. Communication of affect through facial expression in humans. Journal of Personality and Social Psychology, 1972, 23, 362-371.

Buck, R. and Miller, R. Sex, personality and physiological variables in the communication of affect via facial expression. Journal of Personality and Social Psychology, 1974, 30(4), 587-596.

Cannon, W.B. Bodily Changes in Pain, Hunger, Fear and Rage. New York: Appleton, 1915.

Cannon, W.B. The James Lange theory of emotions: a critical examination and an alterntive theory. American Journal of Psychology, 1927, 39, 106-124.

Chevalier-Skolnikoff, S. Facial expression of emotion in non-human primates. In P. Ekman (Ed.) Darwin and Facial Expression. Academic Press, 1973, 11-90.

Cohen, H.O., Goodenough, D.R., Witkin, H.A., Oltman, P., Gould, H., and Shulman, E. The effects of stress on components of the respiration cycle. Psychophysiology, 1975, 12(4), 377-380.

Colby, C.A., Lanzetta, J.T. and Kleck, R.E. Effects of the expression of pain on autonomic and pain tolerance responses to subject-controlled pain. Psychophysiology, 1977, 14(6), 537-540.

Darwin, C. The Expression of the Emotions in Man and Animal. Philosophical Library, New York, 1955 (first edition 1872).

Davidson, R. and Schwartz, G.E. Patterns of cerebral lateralization during cardiac biofeedback vs. the self-regulation of emotion: Sex differences. Psychophysiology, 1976, 13 (1) 62-68.

Davidson, R., Schwartz, G.E., Pugash, E. and Bromfield, E. Sex differences in patterns of EEG assymmetry. Biological Psychology, 1976, 4(2), 119-138.

DeWitt, G. Laterality, Personality, and Emotions: A Search for Relationship. Presented at APA, 1977, San Francisco.

Dixon, W.J. and Brown, M.B. (Eds.). BMDP Biomedical Computer Programs P-Series. University of Chicago Press, 1977.

Drohocki, A. The effect of emotion on the amplitude spectogram of the EEG. EEG and Clinical Neurophysiology, 1974, 36(4), 426.

Erlichman, H. and Wiener, M.S. Dimensions of EEG Assymmetry During Covert Mental Activity. Paper presented at American Psychological Association, 1977.

Ekman, P. Universals and cultural differences in facial expressions of emotion. Nebraska Symposium on Motivation, 1971.

Ekman, P. Cross-cultural studies of facial expression. In P. Ekman (Ed.) Darwin and Facial Expression. Academic Press, 1973, 169-222.

Ekman, P. and Friesen, W.V. A tool for the analyses of motion picture film or videotape. American Psychologist, 1969, 24(3), 240-243.

Ekman, P. and Friesen, W.V. Detecting deception from the body or face. Journal of Personality and Social Psychology, 1974, 29(3), 288-298.

Ekman, P. and Friesen, W.V. Unmasking The Face. Eaglewood Cliffs, New Jersey: Prentice-Hall, 1975.

Ekman, P. and Friesen, W.V. Measuring facial movement. Environmental Psychology and Nonverbal Behavior, 1976, 1(1), 56-75.

Ekman, P. and Friesen, W.V. The Facial Action Coding System (FACS). Palo Alto: Consulting Psychologists Press, 1978a.

Ekman, P. and Friesen, W.V. Guide to the Investigator in the Use of FACS. Palo Alto: Consulting Psychologist Press, 1978b.

Ekman, P. and Friesen, W.V. personal communication, 1979.

Ekman, P., Friesen, W.V. and Ancoli, S. manuscript in preparation.

Ekman, P., Friesen, W.V. and Ellsworth, P. Emotion in the Human Face. New York: Pergamon Press, Inc., 1972.

Ekman, P., Friesen, W.V. and Tomkins, S. Facial affect scoring technique: A first validity study. Semiotica, 1971, 3(1), 37-58.

Ekman, P., Malmstrom, E. and Friesen, W.V. Heart Rate Changes with Facial Displays of Surprise and Disgust. Paper presented at Western Psychological Association, 1971.

Ekman, P. and Oster, H. Facial expressions of emotion. Annual Review of Psychology, 1979, 30, 527-554.

Ekman, P., Sorenson, E.R. and Friesen, W.V. Pan-cultural elements in facial displays of emotion. Science, 1969, 164(3875), 86-88.

Ellsworth, P. personal communication, 1976.

Engel, B. Stimulus-response and individual response specificity. Archives of General Psychiatry, 1960, 2, 305-313.

Fair, P. Patterns of facial myoelectric activity during affective imagery. Ph.D. dissertation, Harvard University, 1976.

Fair, P. and Schwartz, G.E, Facial muscle patterning to affective imagery and the voluntary expression of emotion. Paper presented at the Society for Psychophysiological Research, 1976, San Diego.

Funkenstein, D.H. The physiology of fear and anger. Scientific American, 1955, 192(5), 74-80.

Funkenstein, D.H. Non-epinephrine-like and epinephrine-like substances in relation to human behavior. Journal of Nervous and Mental Diseases, 1956, 124, 58-68.

Gainotti, G. Emotional behavior and hemispheric side of the lesion. Cortex, 1972, 8, 41-55.

Geer, J. Fear and autonomic arousal. Journal of Abnormal Psychology, 1966, 71, 253-255.

Gellhorn, E. Recent contributions to the physiology of the emotions. Psychiatric Research Reports, 1960, 12, 209-223.

Gellhorn, C. Motion and emotion: The role of proprioception in the physiology and pathology of the emotions. Psychological Review, 1964, 71, 457-472.

Gordon, H.W. and Bogen, J.E. Hemispheric lateralization of singing after intracaratid sodium amylobarbitone. Journal of Neurology, Neurosurgery and Psychiatry, 1974, 37, 727-738.

Graham, D.T. Some research on psychophysiologic specificity and its relation to psychosomatic disease. In R. Roessler, and N.S. Greenfield (Eds.) Physiological Correlates of Psychological Disorders. University of Wisconsin Press, Madison, Wisconsin, 1962.

Graham, D.T., Stern, J. and Winokur, G. The concept of a different specific set of physiological changes in each emotion. Psychiatric Research Reports, 1960, 12, 8-15.

Greenblatt, M. Autonomic responses and emotions: Further discussion. In P.H. Knapp (Ed.) Expression of the Emotions in Man. New York: International University Press, 1963, 199-205.

Greene, R.L. Lateralization of visual input and bilateral electrodermal reactivity. Psychophysiology, 1978, 15(3), 267.

Harman, D.W. and Ray, W.S. Hemispheric activity during affective verbal stimuli: An EEG study. Neuropsychologia, 1977, 15, 457-460.

Heilman, K., Scholis, R. and Watson, R. Auditory affective agnosia. Journal of Neurology, Neurosurgery and Psychiatry, 1975, 38, 69-72.

Hord, D.J., Johnson, L. and Lubin, A. Differential effects of the LIV on autonomic variability. Psychophysiology, 1964, 1, 79-87.

Izard, C.E. The Face of Emotion. New York: Appleton-Century-Crofts, 1971.

Izard, C.E. Human Emotions. New York: Plenum Press, 1977.

Jacobson, E. Progressive Relaxation. Chicago: University of Chicago Press, 1938.

Jacobson, E. Biology of Emotions. Springfield, Illinois: Charles C. Thomas, 1967.

James, W. What is emotion? Mind, 1884, 9, 188-204.

James, W. The emotions. In K. Dunlap (Ed.): The Emotions by C.G. Lange and William James, Vol. 1. Baltimore: Williams and Wilkins Co., 1922., 93-135.

Jasper, H.H. The ten-twenty electrode system of the international federation. EEG and Clinical Neurophysiology, 1958, 27, 30-35.

Johnson, L., Hord, D. and Lubin, A. Response specificity for difference scores and autonomic lability scores. U.S. Navy Medical Neuropsychiatric Unit, Report 63-12, August, 1963.

Jones, H.E. The Galvanic Skin Reflex as related to overt emotional expression. American Journal of Psychology, 1935, 47, 241-251.

Kleck, R.E., Vaughan, R.G., Cartwright-Smith, J., Vaughan, K.B., Colby, C.Z. and Lanzetta, J.T. Effects of being observed on expressive, subjective, and physiological responses to painful stimuli. Journal of Personality and Social Psychology, 1976, 34(6), 1211-1218.

Lacey, J.I. The evaluation of autonomic responses: Toward a general solution. Annals of the New York Academy of Science, 1956, 67, 123-164.

Lacey, J.I. Somatic response patterning and stress: Some revisions of activation theory. In M.H. Appley and R. Trumbull (Ed.) Psychological Stress. New York-Appleton-CenturyCrofts, 1967.

Lacey, J.I., Bateman, D. and Van Lehn, R. Autonomic response specificity: An experimental study. Psychosomatic Medicine, 1953, 15, 8-21.

Lacey, J.I., Kagen, J., Lacey, B.C. and Moss, H.A. The visceral level: Situational derterminants and behavioral correlates of autonomic response patterns. In P.A. Knapp (Ed.) Expression of the Emotions in Man. New York: International University Press, 1963, 161-196.

Lacey, J.I. and Lacey, B.C. Verification and extension of the principle of autonomic response sterotypy. American Journal of Psychology, 1958, 71, 50-73.

Lacey, J.I. and Lacey, B.C. Law of initial value in the longitudinal study of autonomic constitution: Reproducibility of autonomic responses and responses patterns over a 4- year period. Annals of the New York Academy of Sciences, 1962, 98, 1257-1290.

Lacey J.I. and Lacey, B.C. Some autonomic-CNA interrelationships. In P. Black (Ed.) Physiological Correlates of Emotions, 1970, Academic Press, 205-228.

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

Lange, K. The Emotions. Demark, 1885 (translated by I.A. Haupt for K. Dunlap (Ed.), The Emotions. Baltimore: Williams and Wilkins, 1922).

Lanzetta, J. and Kleck, R.E. Encoding and decoding of nonverbal affect on humans. Journal of Personality and Social Psychology, 1970, 16, 12-19.

Lanzetta, J.T., Cartwright-Smith, J. and Kleck, R.E. Effects of non-verbal dissiumulation on emotional experience and autonomic arousal. Journal of Personality and Social Psychology, 1976, 33(3), 354-370.

Lazarus, R.S., Speisman, J.C., Mordoff, A.M. and Davison, L.A. A laboratory study of psychological stress produced by a motion picture film. Psychological Monographs, 1962, 76, 34 (whole No. 553), 1-35.

Lazarus, R.S. Psychological Stress and the Coping Process. New York: MCGraw-Hill Book Company, 1966.

Lazarus, R.S. Cognitive and personality factors underlying threat and coping. In M.H. Appley and R. Trumbull (Ed.) Psychological Stress: Issues in Research. New York: Appleton-Century-Crofts, 1967.

Lazarus, R.S. The self-regulation of emotion. In Levi, L. Emotions - Their Parameters and Measurements. Raven Press, 1975, 47-67.

Mandler, G. Mind and Emotion. New York: John Wiley and Sons, Inc., 1975a.

Mandler, G. The search for emotion. In L. Levi (Ed.) Emotions - Their Parameters and Measurement, New York: Raven Press, 1975b, 1-15.

Myslobodsky, M.S. and Rattok, J. Assymmetry of electrodermal activity in man. Bulletin of Psychonomic Society, 1975, 6(5), 501-502.

Oken, D., Grinker, R.R., Heath, H.A., et al. Relation of physiological response to affect expression: Including studies of autonomic response specificity. Archives of General Psychiatry, 1962, 6, 336-351.

Plutchik, R. The Emotions: Fact, Theories and a New Model. New York: Random House, 1962.

Plutchick, R. Psychophysiology of individual differences with special reference to emotions. Annals of the New York Academy of Science, 1966, 134, 776-781.

Plutchik, R. and Ax, A. A critique of "Determinants of Emotion State" by Schachter and Singer. Psychophysiology, 1967, 4, 79-82.

Prideaux, E. Expression of the emotions in cases of mental disorders. British Journal of Medical Psychology 1922, 2, 45.

Rosadine, A.G. and Rossi, G.F. Psychic reactions associated with intracarotid sodium amytal injection and relation to brain damage. Excerpta Medica International Congress Series, 1961, 37, 154-155.

Rossi, G.F. and Rosadine, G. Experimental analysis of cerebral dominance in man. In C.H. Millekan and F.L. Dorly (Eds.) Brain Mechanisms Underlying Speech and Language. New York: Greene and Stratton, 1967, 167-184.

Schachter, S. and Singer, J. Cognitive, social and physiological determinants of emotional state. Psychological Review, 1962a, 69, 379-399.

Schachter, S. and Wheeler, L. Epinephrine, chlorpromazene and amusement. Journal of Abnormal and Social Psychology, 1962b, 65(2), 121-128.

Schlanger, B.B., Schlanger, P. and Gerstman, L.J. The perception of emotionally toned sentences by right-hemisphere damaged and aphasic subjects. Brain and Language, 1976, 3(3), 396-403.

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

Schwartz, G.E. Self-regulation of response patterning: Amplications for psychophysiological research and therapy. Biofeedback and Self-Regulation, 1976, 1, 7-30.

Schwartz, G.E. Biofeedback and physiological patterning in human emotion and consciousness. In J. Beatty and H. Lezeivie (Eds.) Biofeedback and Behavior. New York: Plenum Press, 1977, 293-306.

Schwartz, G.E, Davidson, R. and Maer, F. Right hemisphere lateralization for emotion in the human brain: Interactions with cognition. Science, 1975, 190, 286-288.

Schwartz, G.E., Fair, P., Salt, P., Mandel, M. and Klerman, G.L. Facial muscle patterning to affective imagery in depressed and non-depressed subjects. Science, 1976a, 192, 489-491.

Schwartz, G.E., Fair, P.L., Salt, P., Mandel, M.R. and Klerman, G.L. Facial expression and imagery in depression: An electromyographic study. Psychosomatic Medicine, 1976b, 38(5), 337-347.

Sternbach, R.A. Assessing differential autonomic patterns in emotions. Journal of Psychosomatic Research, 1962, 6, 87-91.

Sternbach, R.A. Principles of Psychophysiology. New York: Academic Press, 1966.

Stoyva, J. and Kamiya, J. Electrophysiological studies of dreaming as the protoptype of a new strategy in the study of consciousness. Psychological Review, 1968, 75(3), 192-205.

Tomkins, S.S. Affect, Imagery and Consciousness, Vol. I. The Positive Affects. New York: Springer, 1962.

Tomkins, S.S. Affect, Imagery and Consciousness. Vol. II. The Negative Affects. New York: Springer, 1963.

Tomkins, S.S. The Phantasy Behind the Face. Journal of Personality Assessment, 1975, 39(6), 551-562.

Tomkins, S.S. and McCarter, R. What and where are the primary affects? Some evidence for a theory. Perceptual and Motor Skills, 1964, 18, 119-158.

Toomim, M. personal communication, 1976.

Wenger, M.A. Emotion as visceral action: An extension of Langes Theory. In M.L. Reymert (Ed.), Feelings and Emotion, New York: McGraw-Hill, 1950, 3-10.

Wenger, M.A., Engel, B., Clemens, B.T. and Cullen, T.D. Autonomic response specificity. Psychosomatic Medicine, 1951, 23, 185-193.

Wilson, G. GSR responses to fear-related stimuli. Perceptual and Motor Skills, 1967, 24, 401-402.

Wolf, S. Emotions and the ANS. Archives of Internal Medicine, 1970, 126(6), 1024-1030.

Zung, W.K. A self-rating depression scale. Archives of General Psychiatry, 1965, 12, 63.

Appendix A Subject Consent Form

UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

CONSENT TO ACT AS RESEARCH SUBJECT

1. I hereby agree to have Dr. J. Kamiya and or Sonia Ancoli perform the following procedures on me for experimental purposes, and I consent to participate in these procedure:

a) attachment of electrodes to my scalp, my shoulders, my hands and arms, and my chest and abdomen.

b) to view movies of pleasant an unpleasant content.

c) to describe my feelings about these movies.

d) to respond to questionnaires and answer the questions of standarized personality tests.

2. These procedures will be done in 1428 Fifth Avenue, San Francisco, and will take the following amount of time: about 1½ hours.

3. The purpose of performing these procedures is: to further the understanding of human responses to pleasant and unpleasant situations.

4. I understand that the procedures described in section I involve the following risks and/or discomforts:

a) minor skin irritation from electrode paste, but this is rare.

b) possible discomfort due to the viewing of any unpleasant movies.

5. I understand that the results of this study will be of no direct benefit for me, but that it will further basic scientific knowledge.

6. This information has been explained to me by Sonia Ancoli. I understand that she will answer any questions I may have concerning the procedures at any time following the completion of the experimental session. I may reach her at 681-8080, ext. 405.

7. I understand that my participation in this study is entirely voluntary and that I may decline to enter this study or may withdraw from it at any time without jeopardy. I understand that the experimenter may drop me from the study as long as it is not detrimental to me. I understand that my behavior in this research will be treated in a manner so as to attempt to maintain my anonymity.

8. I understand that my payment for participation in this investigation is $3.00. If I do not complete this study, I will receive a minimum of $2.00 if I participate longer than ½ hour.

Subject ______________________________

Date ______________________________

Appendix B Zung Depression Scale

Please rate the following items as to how each applies to you at this time. Rate each question as either:

1. a little of the time
2. some of the time
3. good part of the time
4. most of the time

1. I feel down-hearted and blue. ________
2. Morning is when I feel the best. ________
3. I have crying spells or feel like it. ________
4. I have trouble sleeping at night. ________
5. I eat as much as I used to. ________
6. I still enjoy sex. ________
7. I notice that I am losing weight. ________
8. I have trouble with constipation. ________
9. My heart beats faster than usual. ________
10. I get tired for no reason. ________
11. My mind is as clear as it used to be. ________
12. I find it easy to do the things I used to. ________
13. I am restless and can't keep still. ________
14. I feel hopeful about the future. ________
15. I am more irritable than usual. ________
16. I find it easy to make decisions. ________
17. I feel that I am useful and needed. ________
18. My life is pretty full. ________
19. I feel that others would be better off if I were dead. ________
20. I still enjoy the things I used to do. ________

Name__________________________________

Date__________________________________

Time__________________________________

Appendix C Self-Report Rating Information and Forms

NAME____________________OCCUPATION____________________

AGE____________If student, YEAR IN SCHOOL______DATE____________

BIRTHPLACE____

If your parents were not born in the United States, please indicate their place of birth:

MOTHER____________________FATHER____________________

How many hours did you sleep last night?______________

When was the last time you ate?____________________

Time now__________________________________

You will be rating yourself on the strength of: INTEREST, ANGER, DISGUST, FEAR, HAPPINESS, PAIN, SURPRISE, and general emotional AROUSAL. For each, you will give a score, rangind from 0 to 8. Zero is used for "neutral" or "not present." One is used for a "weak" feeling, four is used for a "moderate" feeling, and eight is used for a "stong" feeling.

Strength should be viewed as a combination of (a) the number of times you felf the emotion -- its <u>frequency</u>; (b) the length of time you felt the emotion -- its <u>duration</u>; and (c) how intense or extreme the emotion was -- its <u>intensity</u>. You may use any or all of these reasons (a, b and/or c) to determine the strength or importance of each emotion. You may change your reasons or may weight your reasons differently for each of the clips you see.

Let's take an example. You may see a clip in which you felt relatively <u>strong</u> <u>INTEREST</u> <u>throughout</u>. Once during the clip, you felt <u>brief</u> <u>but</u> <u>intense</u> <u>ANGER</u>. You started <u>UNAROUSED</u>, but during and after the <u>ANGER</u> feeling, you were very <u>AROUSED</u> for the rest of the clip. Taking the frequency, duration and intensity of each emotion into account, you might rate such a feeling as follows:

Telephone Number________________________________

Address______________________________________

Social Security Number____________________________

Date of last period______________________________

	INTEREST	ANGER	DISGUST	FEAR	HAPPINESS	PAIN	SADNESS	SURPRISE	AROUSAL
NEUTRAL:	0	0	0	0	0	0	0	0	0
WEAK:	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3
MODERATE:	4	4	4	4	4	4	4	4	4
	5	5	5	5	5	5	5	5	5
	6	6	6	6	6	6	6	6	6
	7	7	7	7	7	7	7	7	7
STRONG:	8	8	8	8	8	8	8	8	8

In rating the clip, you circle the appropriate number from 0 to 8 for each of the emotions listed across the page. Since DISGUST, FEAR, HAPPINESS, PAIN, SADNESS, and SURPRISE were not judged as present, they would be rated as "neutral" or "not present." You must CIRCLE A NUMBER FROM 0 TO 8 FOR EVERY ONE OF THE EMOTIONS GIVEN AT THE TOP OF EACH COLUMN.

In scoring INTEREST, zero is used for "no interest" or active "disinterest." For example, your attention may wander. Even though you may feel relatively little interest in the film, you may still have fairly strong emotional feelings. Similarly, even though you feel little interest, you may be in a moderate or even strong state of arousal. Please note that you could feel emotional arousal with either pleasant or unpleasant emotion.

AROUSAL is an index of the total emotional state -- regardless of the specific emotions. AROUSAL may be associated with negative emotions such as ANGER and DISGUST. AROUSAL may be associated with INTEREST and SURPRISE. AROUSAL may be associated with positive feelings, such as HAPPINESS. Or, AROUSAL may arise from <u>both</u> positive and negative emotions. Logically, if most of the emotions are scored as "neutral" or "weak," AROUSAL will be scored as "weak." If one or more emotions are very "strong", AROUSAL is likely to be scored as "strong."

PAIN is defined here as the amount of <u>empathetic</u> <u>PAIN</u> you felt while watching the film clips. In scoring PAIN, you would circle zero if you felt no empathetic PAIN; you would circle one if you felt weak empathetic PAIN. For example, if during the clip you experience stron empathetic PAIN, you would circle 7 or 8. PAIN DOES <u>NOT</u> REFER TO ANY UNCOMFORTABLE FEELINGS YOU FEEL BECAUSE OF THESE SURROUNDINGS. IT <u>DOES</u> REFER ONLY TO THE <u>EMPATHETIC</u> <u>PAIN</u> FEELINGS YOU MAY HAVE BECAUSE OF THE FILM CLIPS.

While the clips are relatively short, you may feel several different emotions during one clip. For example, you may feel relatively little INTEREST throughout but feel moderate DISGUST for a long period of time, as well as several moderate PAIN responses, and a very brief but intense SAD reaction. Overall, you feel somewhat AROUSED during most of the clip. Again, taking the frequency, duration and intensity of each emotion into account, you might rate such a feeling as follows:

	INTEREST	ANGER	DISGUST	FEAR	HAPPINESS	PAIN	SADNESS	SURPRISE	AROUSAL
NEUTRAL:	0	0	0	0	0	0	0	0	0
WEAK:	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3
MODERATE:	4	4	4	4	4	4	4	4	4
	5	5	5	5	5	5	5	5	5
	6	6	6	6	6	6	6	6	6
	7	7	7	7	7	7	7	7	7
STRONG:	8	8	8	8	8	8	8	8	8

In this case, ANGER, FEAR, HAPPINESS and SURPRISE were not judged as present and they would be scored as zero -- "neutral" or "no present."

You may feel several emotions, and you may feel both positive and negative emotions in the same clip. For example, you might see a clip where you feel a very intense and long lasting DISGUST, a brief feeling of HAPPINESS, a couple of mild PAIN responses, and very weak SADNESS, INTEREST, AND SURPRISE. Given the number and intensity of emotions, AROUSAL might appear quite strong. You might rate such a clip as follows:

	INTEREST	ANGER	DISGUST	FEAR	HAPPINESS	PAIN	SADNESS	SURPRISE	AROUSAL
NEUTRAL:	0	0	0	0	0	0	0	0	0
WEAK:	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3
MODERATE:	4	4	4	4	4	4	4	4	4
	5	5	5	5	5	5	5	5	5
	6	6	6	6	6	6	6	6	6
	7	7	7	7	7	7	7	7	7
STRONG:	8	8	8	8	8	8	8	8	8

There is no limit to the number of emotions you choose to indicate as present. In this case, the only emotions on the list that were not present were ANGER and FEAR. These were circles as zero for "neutral" since they were not present.

Finally, there may be some clips where you feel no emotion whatsoever, and are disinterested in the film. You would rate such a clip as follows:

	INTEREST	ANGER	DISGUST	FEAR	HAPPINESS	PAIN	SADNESS	SURPRISE	AROUSAL
NEUTRAL:	0	0	0	0	0	0	0	0	0
WEAK:	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3
MODERATE:	4	4	4	4	4	4	4	4	4
	5	5	5	5	5	5	5	5	5
	6	6	6	6	6	6	6	6	6
	7	7	7	7	7	7	7	7	7
STRONG:	8	8	8	8	8	8	8	8	8

Here it must be emphasized that you are <u>not</u> to circle "0" for NEUTRAL if you are in doubt about the emotion(s) felt. YOU WOULD ONLY CIRCLE "0" FOR ALL THE LISTED EMOTIONS ONLY IF THERE WAS NO EMOTION FELT WHATSOEVER. Sometimes you may feel uncertain about your judgements. If you are uncertain, please make your best possible guess. We have found in past research that even when people feel uncertain their guesses are often very accurate and provide very useful data.

To summarize, you will be watching two films, each of three clips. After each film rate each clip on every emotion scale from "0" for NEUTRAL to "8" for VERY STRONG depending on its strength. Base this rating on the frequency, duration and/or the intensity of the emotion felt.

NAME________________________________ FILM________

CLIP________

	INTEREST	ANGER	DISGUST	FEAR	HAPPINESS	PAIN	SADNESS	SURPRISE	AROUSAL
NEUTRAL:	0	0	0	0	0	0	0	0	0
WEAK:	1	1	1	1	1	1	1	1	1
	2	2	2	2	2	2	2	2	2
	3	3	3	3	3	3	3	3	3
MODERATE:	4	4	4	4	4	4	4	4	4
	5	5	5	5	5	5	5	5	5
	6	6	6	6	6	6	6	6	6
	7	7	7	7	7	7	7	7	7
STRONG:	8	8	8	8	8	8	8	8	8

Appendix D Post-Experiment Consent Form

UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

CONSENT TO ACT AS RESEARCH SUBJECT

I have been informed that a videotape of me has been recorded during the experimental session. This tape is for research purposes only.

I understand that the reason I was not informed about the videotape previously is because it is thought that people who know that they are being filmed may not act in a natural and spontaneous manner.

By signing this form, I give my permission for the tapes to be kept and used for research purposes. I understand that if I do not wish to have these videotapes used, I do not have to sign below and the tapes will be erased.

Name______________________________

Date______________________________

Appendix E Instructions to FACS Coders

Instructions for Coding

1. Do not score head and eye movements if no other AU's occur. NOTE: Subjects had to look down a little to see the film. If scoring HEAD DOWN, make sure the movement was not just one necessary to see the film.

2. Record only onset and offset times. Do not record apex. If trace of second AU is within 15 fields of first, consider same onset time.

3. The numbers 1 vs. 2 on your list = There are two sets of film for each S. The three digit numbers always begin at 000. The 6 digit numbers begin at 000000 only at the first set (1). Therefore, check the six digit numbers to see if you are at the first or second set. NOTE: Subject number six has only one set and has been eliminated.

4. Example of coding:
a) If 12x + 25 is from 000110 - 000250 and then 4 is added until 000780, code 000110 - 000250 12x + 25
000251 - 000780 4 + 12x + 25

b) If R2 is only present for an instant, but 12x continues, code: 000059 - 000062 R2 + 12x
000062 - 000127 12x

5. There will be some cases where an AU is present throughout the entire film. Do not code that AU unless it changes in intensity (in either direction) and another AU is present.
ex. AU 4 might be present from beginning to end, but only gets scored if it gets weaker or stronger and other AU's are added.

6. When given 30 sec. epochs to code:
   a) if an AU is already in progress at start of epoch, go back to onset time
   b) if an AU is still in progress at end of epoch, continue coding until offset time.

Appendix F Determination of Positive and Negative Facial Responses

The following is a brief description to determin if a facial response is positive or negative. These descriptions are not complete and are only examples. For a more complete description, the reader is referred to Ekman and Friesen's Unmasking the Face (1975) and their Facial Action Coding System (FACS) (1978).

Positive Faces:

Positive faces are seen in the lower face and lower eyelids. The characteristics as reported by Ekman and Friesen (1975;1978) are:

1. Corners of the lips are drawn back and up. In FACS this is called a lip corner pull (LCP) or AU12. Action unit 12 is also scored for intensity.

2. Cheeks are raised (AU6).

3. Lower eyelid shows wrinkles below it.

4. Crow's feet wrinkles may go outward from the outer corner of the eyes . A face scored as AU12 or AU6 + 12 could be interpreted as happy.

Negative Faces:

Negative faces can be characterized by some combination (blend) of the following:

1. Nose wrinkle (AU9; disgust)

2. Upper lip raise (ULR). This is also scored for intensity (AU10; disgust)

3. Raised brow (AU1 + 2 or AU1 + 2 + 4; fear)

4. Wide open eyes (AU5; fear). This AU is also scored for intensity.

5. Open mouth (AU 25, 26 _or_ 27; fear)
6. Inner corners of eyebrows drawn up (AU 1 + 4; sad)
7. Corners of the lips drawn down (AU 15; sad)

Appendix G Results of Facial Coding

I. Facial Activity

A. Reliabilities in the Location of Facial Action

A total of 45 facial activity events and 31 facial activity events were scored by the two coders in Parts I and II respectively (recall that Part I consisted of a random selection of one film from each of the first 10 Ss and Part II consisted of a 30-second epoch from each of the remaining 25 Ss). Reliability was first determined for location. Since location was not taught to coders instructed in FACS, no previous reliabilities were available for comparison.

One way to regard location was as a binary decision - something was happening or not at each frame in time. When occur vs. no-occur decisions are made point-by-point in time, a common way to assess reliability is to determine whether two independent coders agree for each point in time. Agreement is then represented as a percent of total time considered (Ekman & Friesen, 1978 - grant). This was done for each 1/10 of a second in Parts I and II. As can be seen in Table IX, the two coders agreed as to whether or not an event had occured 89% of the time in Part I and 95% of the time in Part II. Since this method of calculating reliabilities gives equal credit to agreement that nothing happened and agreement that something did happen, the result could be inflated if the sampe contained long stretches of time in which the face was inactive. Inactive is defined as either no visable movement or movement that was not scorable. To assure good inter-coder reliability, FACS has set rules as to a minimum threshold below which a facial movement can not be scored. If a facial activity does not meet these minimum requirements demanded by FACS, it is not coded. In Part I, the face was inactive or not scorable 69% of the time; in Part II, the face was inactive or not scorable 66% of the time.

TABLE IX

Total Number of Seconds of Action vs. No-action

	Part I	Part II
Total # of secs.	1320	780
agreement	1176.87	743.79
disagreement	143.13	36.30
% agreement	89%	95%

Another way to examine agreement about location, which avoids the problem of inflating the estimate by agreements regarding no action, is to examine the occurrence of complete disagreements. The worst error in location is when one coder scores an event which the other failed to score (either because they missed the event entirely or judged it as not reaching the minimum requirements dictated by FACS). In Part I such complete disagreement occurred on 18.4% (8 events) of the behavior scored; in Part II such complete disagreement occurred on 12.9% (4 events of the behavior scored).

The question of the reliability of location determination was studied in more detail by examining exactly how close the time markings were for the onset and offset of each event. Table X summarizes these results. The percentage of agreement was calculated with the total number of events scored by both coders (including events seen by only one, and in Part II, 13 events that were scored as total time being neutral) as the denominator. As can be seen, agreement was more precise on onset than offset, perhaps due to the difficulty of determining when a fading action stopped meeting the minimum requirements of FACS. Agreement was also higher in Part II than Part I, perhaps because of experience (as mentioned above, FACS does not deal with location. Therefore neither coder had had any previous experience with determining onset and offset of an action).

If one looks at the mean disagreement in time for onset and offset, the results are 0.67 sec and 0.66 sec difference in onset for Parts I and II respectively, and 2.28 sec and 1.79 sec for offset.

TABLE X

PERCENT OF TOTAL EVENTS LOCATED

		PART I (n=44)	PART II (n=31)
agree on onset within:	1/10 sec	25.0	64.5
	1/2 sec	59.1	74.2
	1 sec	70.5	83.9
	2 sec	77.3	83.9
agree on offset within:	1/10 sec	13.6	61.3
	1/2 sec	38.6	67.7
	1 sec	50.0	77.4
	2 sec	68.2	77.4
agree on both onset & offset within:	1 sec	47.7	74.2
	2 sec	68.2	74.2

B. Classification Reliability

Forty-five events were scored in Part I. Of these, 36 events were scored as a facial action by both coders, one event was scored by both as neutral, and eight events were scored by only one coder (non-overlap events). The resulting classification reliabilities are presented in Table XI. For all 45 events, the reliability was .722; when the non-overlapping events are omitted, reliability becomes .878. If only those events that both coders scored as being active in facial action are considered, r = .875. This reliability was considerably higher than that reported by Ekman and Friesen (1977) for the inter-reliability for coders trained in FACS (r = .756).

Part II consisted of a total of 31 facial activity events: 14 scored by both coders as active facial activity, 13 scored by both coders as neutral, and 4 scored by only one coder. As can be seen in Table XI (Part II-A) the resulting reliabilities were lower than those in Part I as well as being lower than the reliabilities reported for coders in the FACS training manual (Ekman and Friesen, 1973). When the data from this section was examined in more detail, it became clear that a high frequency of disagreements occurred in those areas where discrimination is not usually difficult, i.e. lips parted (AU 25) jaw drop (AU 26) and head position. This was mentioned to coder 2, who stated that she had not re-read her instructions and thought that those action units (facial behaviors) were unimportant for the purposes of this study. It was therefore decided that both coders would re-score the four events where obvious "careless" errors had been made. Reliability was then recalculated with the resulting reliabilities being .791 for all events (n=31), .909 for only those events scored by both coders

TABLE XI

Classification Reliability Coefficients

	All events scored (including non-overlap events)	Events scored by both coders only	Events scored by both coders excluding neutrals
Part I	.722 (n=45)	.878 (n-37)	.875 (n=36)
Part II-A	.735 (n=31)	.844 (n=27)	.699 (n=14)
Part II-B	.791 (n=31)	.909 (n=27)	.824 (n=14)
Parts I & II-B	.757 (n=76)	.893 (n=64)	.850 (n=50)

(n=27) and .824 for those events socred by both as facial action (n=14) (Table XI,Part II-B). This raised the question of which coder attitude in coding and which reliabilities were representative of all the codes. However, since there had been good reliability at the start and good reliability on the other action units, and since the coder that presented the problem did not code all of the data (recall, coder 2 only scored a random sampling), it was decided that the new reliabilities were the more accurate ones.

The events (with neutral omitted) were further distributed into the percent of events for each part (I and II) that fell into each range of reliability coefficients. Fig.10 presents the results of Part I and II.

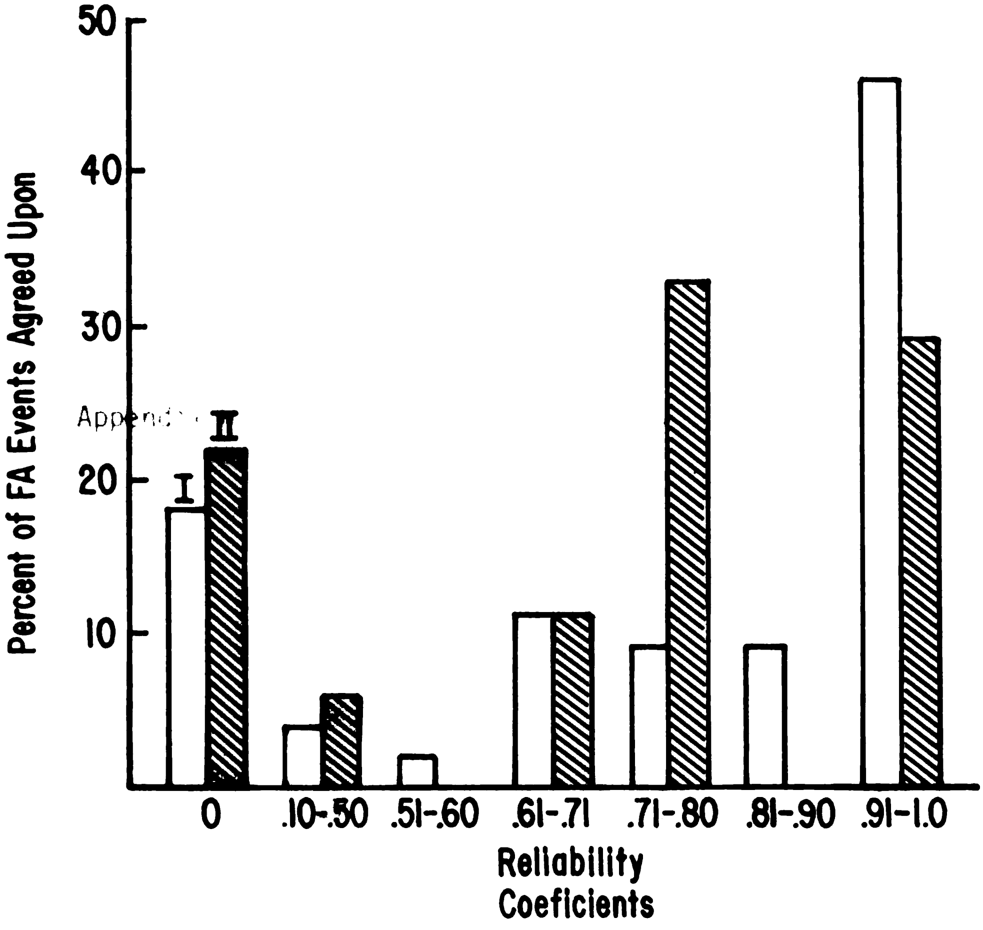


Fig. 10 RELIABILITY AND DISTRIBUTION OF FACIAL ACTIVITY (FA) EVENTS SCORED BY BOTH CODERS IN PART I AND PART II

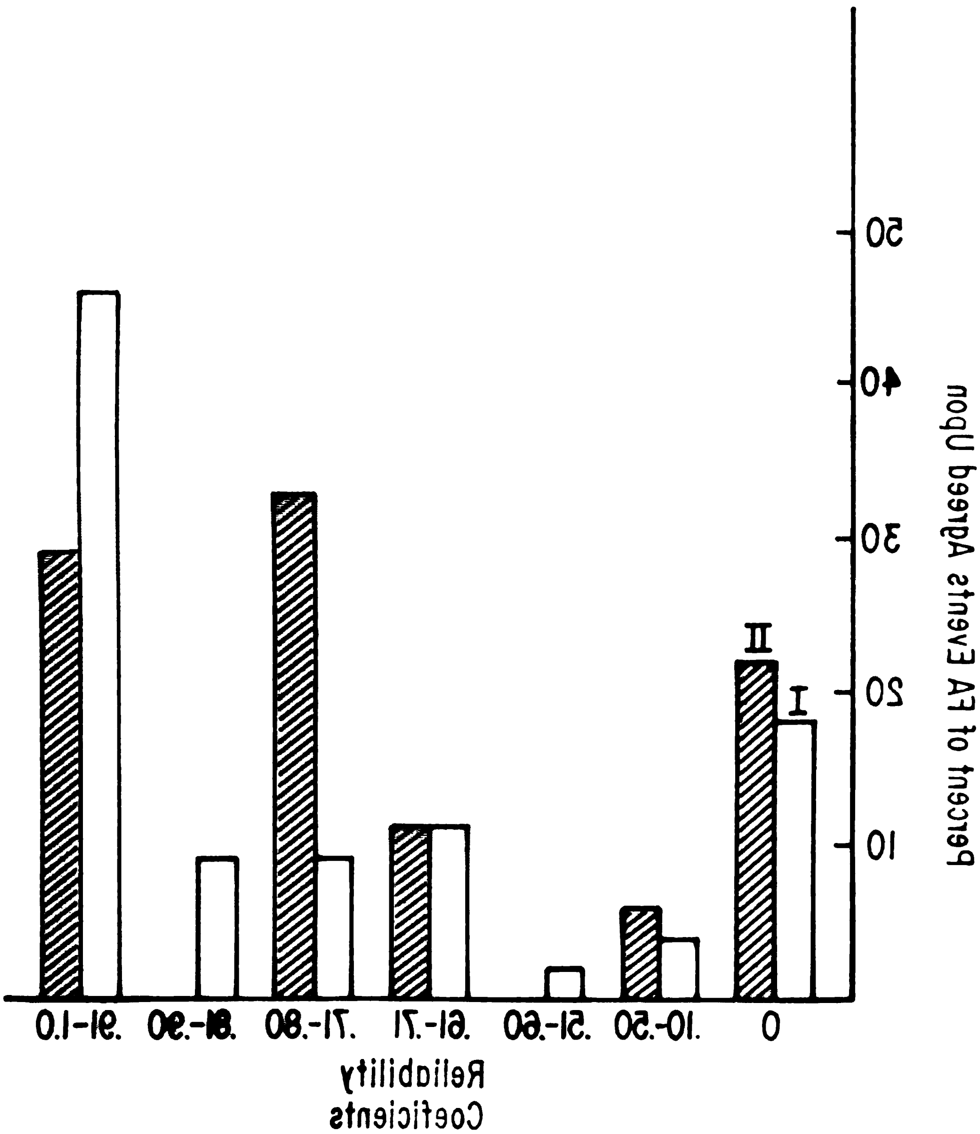


Fig.10 RELIABILITY AND DISTRIBUTION OF FACIAL ACTIVITY (FA) EVENTS SCORED BY BOTH CODERS IN PART I AND PART II

Appendix H Baseline Self-Report Data

Self-Report

Since the presentation of the films had been counterbalanced, Wilcoxin Matched-Pair Signed-Ranks non-parametric tests (Sigel, 1956) were done on the baseline self-report data. Subjects who saw the pleasant film first had higher fear ($p=.02$) responses on their initial pre-pleasant film baseline. This was most likely an anticipation response. Subjects who saw the unpleasant film first, scored happy lower ($p=.05$) on their post-unpleasant film baseline than on their pre-unpleasant film baseline. Interpretation of these data must be made with great caution however, because a separate signed-rank test was computed for each of the nine affects.

The ratings for the pre-pleasant film baseline were also compared to the ratings of the pre-unplesant film baseline for all subjects regardless of order of film presentation. There were no significant differences in any of the baseline affect rating.

Appendix I EEG Data

Standardized EEG DATA

The EEG analyses were performed separately for EEG intensity and for electrode locational indices. The locational indices were based on each of the following ratios: T3A1:T4A2; C3A1:C4A2; T3A1:C3A1; and T4A2:C4A2 (where A1 and A2 represent the left and right ears). The formula for the index was (using T3A1:C3A1 as an example), $\frac{(T3A1)-(C3A1)}{(T3A1 + C3A1)/2}$.

In addition, left (L) to right (R) hemisphere ratios were also examined. The formula used was, (L-R)/(L+R)/2.

Table XII shows the mean standard score data for the EEG intensity, electrode locational indices and the left:right hemisphere indices. Since the numbers are instandard socres, negative numbers represent means that are below that of the initial baseline. The numbers labeled leads represent T3A1, T3A2, C3A1, and C4A2 respectively for leads 1, 2, 3, and 4. The baseline represents the mean of three 20 second baseline segments. For the indices, the numbers 1, 2, 3, and 4 represent the locational indices as listed above, i.e. T3A1:T4A2, etc.

Table XII Standard Scores of EEG data

A. EEG Intensity (Note each number = x 10^{-3})

Frequency	Baseline				Positive Facial Response + High Positive Self-Report				Negative Facial Response + High Negative Self-Report			
Leads:	1	2	3	4	1	2	3	4	1	2	3	4
Theta 1	315	081	058	095	-540	-504	158	-280	027	152	-334	320
Theta 2	050	-099	-245	-023	-157	-084	022	054	137	292	235	190
Alpha 1	122	-095	253	250	-084	-759	-725	-528	-339	533	-055	072
Alpha 2	-162	-301	184	439	317	187	-257	-501	-117	137	-156	-633
Beta 1	-280	-319	032	043	360	249	-373	122	226	564	686	172
Beta 2	-441	-332	024	-013	866	273	-012	159	742	624	376	-115

B. EEG Electrode Location Indices (x10^{-3})

Theta 1	089	031	055	-096	-137	244	-470	-340	023	-833	379	-033
Theta 2	059	-240	-006	-173	-132	255	-163	-071	-107	108	002	209
Alpha 1	224	017	-098	-463	679	-253	696	-317	-907	-206	-323	697
Alpha 2	-103	-166	-349	-524	444	492	485	381	246	197	-006	454
Beta 1	-032	025	-411	-423	062	-409	859	437	097	469	-071	196
Beta 2	-262	060	-682	-431	823	109	929	236	-297	490	614	589

C. Left:Right Hemispher Indices (x10^{-3})

Theta 1	064	-107	-129
Theta 2	-079	-108	-048
Alpha 1	115	358	-524
Alpha 2	-167	721	266
Beta 1	-089	042	212
Beta 2	-223	732	077