Symposium on Emotion

EMOTIONS RESEARCH: Some Promising Questions and Some Questionable Promises

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The study of the emotions makes salient the principal psychophysical question: What is the link between physical changes and subjective experience? In this special issue of *Psychological Science,* the "mind–body" question hovers close to the surface. Psychologists inherited the mind–body problem from philosophers, who have yet to offer a scientifically useful answer. Descartes argued for two distinct processes, psychic and physical, that could interact causally with each other in the pineal gland. The Cartesian dualism was contradicted by Spinoza's parallelism, which postulated two parallel attributes of a single process. Bertrand Russell opposed all forms of dualism, arguing quite convincingly that events can have both the causal relations characteristic of physics and the causal relations typical of psychology. Russell was not at all disturbed by the possibility that events could be at once mental and material. He saw no more difficulty in the matter than in a person being at the same time a carpenter and a father (Russell, 1948).

When brilliant people disagree on an important and difficult issue, it is quite likely that they are each partly correct. Psychology has moved well beyond speculation in formulating and exploring the mind–body problem, and it is fair to say that the field of the emotions holds the best promise for a solution. The reasons for this promise lie in the fact that here we can begin our investigations with data that are directly observable—the emotional expressions. The focus on the more observable to reveal the less observable is the hallmark of emotion research from Darwin on. Because the study of the emotions, under the influence of Ekman (1984) and Izard (1971), began with a focus on the clearly observable correlates—emotional expressions—the field moved ahead systematically, gradually reducing the equations to ever fewer unknowns. In another area—physiological measurement—growing precision was achieved because research took expressions as a standard against which the physiological responses could be coordinated (e.g., see Tassinary and Cacioppo's discussion of electromyography in this issue); there has been equal growth of sophistication in the study of subjective experience, and for the same reason.

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EMOTIONS AND CULTURE

An important way of examining how the mind and body interrelate is research investigating what culture (see Ekman, this issue) and past experience (see Campos, Bertenthal, and Kermoian, this issue) contribute to variance in the three emotional correlates: subjective experience, expression, and physiological process. There is now much more understanding about the role of cultural factors in the experience of emotions, although we are far from a consensus about their role. Theories of emotion range from those espousing a total cultural determinism (Lutz, 1986) to those that have a strong focus on the biological substrate and ignore culture altogether (Papez, 1937). The influence of culture has been usefully conceptualized by the idea of *display rules* (Ekman, 1984). However, while the concept is helpful in guiding observations of cultural elements that enter the emotional sequence, it may cause us to commit prematurely to a theory that holds as universal all that is internal in emotion—subjective experience and neurophysiological process. Modifiable then would be only expressions and their meanings. A more neutral concept, such as *efference norms,* makes no such assumptions. Since we do not yet know all the conditions under which the emotional sequence triggers expressive action and the conditions under which facial action itself elicits subjective states, the matter should not be conceptually preempted. And it is an empirical question of some importance to discover whether subjective states themselves—not merely their displays—can be influenced by culture and what, under these circumstances, their psychophysiological correlates are.

In considering emotions and culture, Ekman (this issue) raises questions about which aspects of facial expressions are universal and which are socially influenced. This issue is fundamental to understanding emotions. Evolutionary antecedents leading to the assumption of a universal psychophysiological substrate for the emotions would be better understood if the genetic elements in emotions were more fully explored. Studies such as Gabbay's (this issue) are therefore welcome and have a promising future. Another important source of variation is to be found in the eliciting stimulus and its cognitive representation, as shown by Mineka and Sutton in this issue, and previously in a number of other studies (Ellsworth, 1991; Smith & Ellsworth, 1985). It is in the realm of cognitive representations of the emotions that we can best approach the important questions about the influence of culture and past experience.

HOW ARE FEELING STATES AND BODILY STATES INTERCONNECTED?

The key to rapid theoretical development is understanding the connection between the subjective realm of the emotions and their neurophysiological substrate. At its most basic level, the psychophysical question in the realm of the emotions reduces to "What is it that we feel when we feel happy, sad, or disgusted?" Recently, evidence that suggests a possible answer has been accumulating. One way in which facial action may change affect is by influencing brain temperature. Recent work seems to indicate that facial action can alter hypothalamic temperature, and that temperature changes are associated with changes in subjective experience (Berridge & Zajonc, 1991; McIntosh, Zajonc, Vig, & Emerick, 1991; Zajonc, Murphy, & Inglehart, 1989). Facial action, it appears, alters the temperature of blood entering the brain by inhibiting or facilitating the cooling process, which may in turn have subjective effects through its impact on the neurochemical activity in the brain—in particular, in the hypothalamus (Berridge & Zajonc, 1991).

Facial action can produce changes in brain blood temperature that, in turn, have significant hedonic consequences. Hedonic consequences are obtained for a variety of reasons. A major reason, however, is that subjective changes can arise from changes in hypothalamic temperature that facilitate and block the release and synthesis of a variety of neurotransmitters. Thus, for example, if a certain action of facial muscles results in changing hypothalamic temperature, then norepinephrine might be either partially blocked or released, and the individual might experience calming or excitation. If the change in hypothalamic temperature releases or blocks serotonin, the effect might be correspondingly depressant or antidepressant. Solid experimental evidence for many of these processes is now still lacking. The biochemical methods reviewed by Baum, Grunberg, and Singer in this issue promise, therefore, useful approaches to this research.

The hypothalamus is a crucial structure in this story because the hypothalamus is profoundly involved in both temperature regulation and the emotions. The lateral hypothalamus is the seat of bodily thermoregulation, and the anterior hypothalamus is the seat of brain thermoregulation. Interestingly, many responses that are involved in thermoregulation—shivering, sweating, piloerection, and many others—are also involved in emotional responses (e.g., these phenomena may appear in a fear response). It has been shown recently that some emotion-related processes of the autonomic nervous system (ANS) are also under the control of the lateral hypothalamus. Thus, for example, cardiovascular responses such as are observed under conditions of rage or defense were found to have their source in the lateral hypothalamus-periforniCal region (Smith, DeVito, & Astley, 1990). The hypothalamus is also heavily implicated in the control of aggression, eating, and sex, to mention just a few behaviors that have substantial emotional components.

The particular mechanisms whereby facial efference can induce subjective states need considerably more empirical support, but they are becoming more and more apparent. The cooling of the brain relies heavily on heat exchange in which venous blood cooled by evaporation exchanges heat with arterial blood that enters the brain. In addition, brain temperature is controlled by the temperature of venous blood that reaches the cavernous sinus, a venous configuration enveloping the internal carotid just before the carotid enters the brain. The cavernous sinus participates actively in the regulation of hypothalamic temperature. It is able to perform this function because its veins drain blood from nasal mucosa and are therefore air cooled in the course of normal breathing.

Hypothalamic cooling is thus the key to understanding one aspect of the mind–body problem, and future emotions research will find it fruitful to examine the consequences and antecedents of hypothalamic thermodynamics. That facial action, breathing, and cooling are involved in the mind–body interface is an idea that has been around for more than 2,000 years. The Greek word *psyche*, which means "soul," also means "breath." And the related word *psychien* means "to cool." To Aristotle, the heart was the organ of sense and feeling, and hence always in need of cooling, a process accomplished by the brain. After 23 centuries, we turn again with promise to examine the relation between hypothalamic temperature, emotional states, and emotional expression and seek to isolate the neurochemicals that are involved in these relationships.

DO FEELING STATES HAVE A ONE-TO-ONE CORRESPONDENCE WITH BODILY STATES?

Another aspect of the psychophysical transfer in emotions is also at the heart of one of the longest running debates in emotions research: the question of psychophysical specificity. Is the specificity that characterizes expression and subjective experience reflected in a one-to-one correspondence at the neurophysiological level? The answer to this question seems to be that there is indeed some specificity (Levenson, this issue). Working with a motivational focus, Lang, Bradley, and Cuthbert (this issue) provide good evidence that the appetitive-aversive distinction organizes basic response tendencies. Work by Davidson (this issue) also shows a positive-negative distinction. He reports that approach and withdrawal responses are specialized in the anterior regions of the two cerebral hemispheres. Study after study confirms these early findings, and they are supported by Robinson's research on stroke-elicited depression (Robinson, Kubos, Starr, Rao, & Price, 1984). The problem that emerges for urgent future research is why this lateralization exists. Why should negative affect be in the right hemisphere and positive affect in the left? It has been suggested (Zajonc et al., 1989) that whereas negative emotions require an instrumental response after the eliciting stimulation has taken place, no instrumental response is required following a positive emotion. For the positive emotions, if instrumental responses are made, they are made beforehand, in order to bring about the positive state. Is it possible that, in the case of negative emotions, the differential electroencephalographic activity derives from activation of the motor cortex or some form of cognitive process that is partially mobilized for an incipient adaptive action (escape, attack, etc.)?

Another example of a physiological difference between positive and negative emotions is based on recent work in our laboratory (McIntosh et al., 1991; Zajonc et al., 1989). The vascular theory of emotional efference predicts changes in breathing patterns and temperature related to changes in valence of emotional state. Both breathing and, dependent on it, brain cooling appear to have a systematic effect on subjectively felt positive emotional states. Absence of cooling or warming has repeatedly been found to have negative consequences. No distinctions, however, have been found among the negative emotions. Even at the perceptual level, distinctions among emotions of the same valence are not always possible. Murphy (1990) presented at suboptimal viewing conditions faces expressing the six so-called basic emotions. Subjects were unable to discriminate beyond the positive and negative classes.

When one moves beyond the positive-negative dimension, the picture is much more ambiguous. We reviewed data reported in this special issue and in previous publications in an attempt to detect the degree of correspondence between physiological measures on the one hand and the expressive and subjective correlates of emotions on the other. Table 1 summarizes significant differences reported in a number of studies seeking to establish ANS distinctions among the six "basic" emotions.[1] Data on heart rate, finger temperature, skin resistance (or conductance), and muscle activity produced both by facial action and by imagery were collected in these studies. In the table, differences among emotions are indicated as in contrast tests; that is, within a row, any two emotions that show the same letter were not found to be significantly different from each other on the given measure. Thus, if there were perfect distinctiveness among the emotions, each row would display letters *a* through *f*. This clearly is not the case, and the pattern of differences for a given measure is not the same across studies.

Two overall findings emerge. First, imagery is not a powerful induction that leads to clear ANS differences. Second, heart rate is perhaps the best discriminator of the emotions, whereas muscle activity is the worst. But even heart rate is far from discriminating consistently or

1. If no mention was made of a significant difference between two emotions, we assumed that the difference between them was not significant.

Table 1. *Differences in physiological changes among emotions across studies*

Year	Task	Happiness	Anger	Fear	Sadness	Disgust	Surprise
		Emotion					
		Heart rate					
1983	Face manipulation	a	b	b	b	a	a
1983	Imagery	a	a	a	a	a	a
1983	Face and imagery	a	b	b	ab	ab	ab
1990	Face manipulation[1]	ab	c	c	cb	ad	d
1990	Best faces only[1,2]	a	b	b	b	a	a
1991	Face and imagery	ab	a	ab	a	b	ab
		Finger temperature					
1983	Face manipulation	a	b	a	a	a	a
1983	Imagery	a	a	a	a	a	a
1983	Face and imagery	a	b	ab	ab	ab	ab
1990	Face manipulation[1]	ab	a	b	ab	ab	ab
1990	Best faces only[1,2]	a	b	a	a	a	a
1991	Face and imagery	ab	ab	ab	a	b	ab
		Skin conductance					
1983	Face manipulation	a	a	a	a	a	a
1983	Imagery	ab	a	a	b	a	ab
1983	Face and imagery	a	a	a	a	a	a
1990	Face manipulation[1]	a	b[3]	b	b[3]	b	a
1990	Best faces only[1,2]	a	ab	b	b	b	a
1991	Face and imagery	a	a	a	a	a	a
		Muscle activity					
1983	Face manipulation[4]	a	a	a	a	a	a
1983	Imagery[4]	a	a	a	a	a	a
1983	Face and imagery[4]	a	a	a	a	a	a
1990	Face manipulation[1,5]	a	a	a	a	a	a
1990	Best faces only[1,2,5]	a	a	a	a	a	a
1991	Face and imagery[6]	a	a	b	ab	a	a

Note. Within a row, if two emotions do not have the same letter, a significant difference was reported; 1983 data from Ekman, Levenson, and Friesen, p. 1209; 1990 data from Levenson, Ekman, and Friesen, pp. 369–372; 1991 data from Levenson, Carstensen, Friesen, and Ekman, p. 31.
[1]1990 face manipulation data include 1983 face manipulation data. [2]"Best faces only" is a subset of the data using only those subjects whose facial configurations best resembled the morphology of the associated emotional expression. [3]Differences are marginal in significance. [4]Muscle tension was used to assess muscle activity. [5]The muscle activity variable combined measures of muscle tension (Experiment 1) and somatic activity (Experiments 2 and 3). [6]Somatic activity only was used to assess muscle activity.

fully among the emotions: For example, in one study (Ekman, Levenson, & Friesen, 1983) using facial action, a distinction was found between happiness, disgust, and surprise, on the one hand, and anger, fear, and sadness, on the other, with no distinctions within either of these triads. In the same study, there was a lack of discrimination for an imagery task, even though the same subjects and the same dependent measures were employed.

Evaluating the existence of physical changes during both the posed-face task and a relived-emotions (imagery) task in a group of elderly people, Levenson, Carstensen, Friesen, and Ekman (1991) replicated the finding that heart rate increased more for anger and sadness than for disgust (but the distinction between fear and disgust was not repeated). They also found that finger temperature changes differed for sadness and disgust, a relation not obtained previously. Tourangeau and Ellsworth (1979) also failed to find meaningful distinctiveness between sadness and fear, obtaining correlations of various physiological measures with self-report no higher than .19 and of those measures with facial expression no greater than −.14. More recently, Tassinary, Cacioppo, and Geen (1989) reported another failure to find significant differences in either heart rate or skin conductance when subjects posed "happy" and "angry" expressions, and Rimé, Philippot, and Cisamolo (1990) have concluded that "psychophysiological research failed to establish consistent physiological patterns differentiating emotion" (p. 38).

Should we expect a priori a particular ANS pattern to correspond to each of the different emotions? As has been argued elsewhere (Zajonc et al., 1989), emotional ANS activity occurs for diverse reasons, and this causal diversity does not promise consistency. Different ANS patterns may be brought about just because there are differences in the eliciting stimulus, in the cognitive appraisal, in expressive gestures, or, finally, in instrumental behavior. If, for example, fear brought about by an extremely loud sound shows itself as a strong change in skin resistance and heart rate, we cannot unambiguously regard the change as a unique reflection of fear reaction, and specific to fear alone. Loud sound is capable of causing these reactions whether or not the subject experiences fear. Further, a quite different ANS reaction will be observed when the subject experiences fear of failing an exam. Hence, not all fear reactions will generate the same psychophysiological patterns. We cannot expect the same ANS patterns for all instrumental responses either. A freezing response will generate a different ANS pattern than a fleeing response because they have completely different energy requirements for the organism.

To some extent, the search for emotion specificity is reminiscent of the research history on innate releasing mechanisms (IRMs; Lorenz, 1939; Tinbergen, 1952). IRMs were assumed to be unlearned and unextinguishable processes that evolved because of their adaptive value in eliciting emotion-based instrumental responses, such as flight or attack. Lorenz assumed that there existed for each IRM empirically specifiable neurophysiological programs capable of being triggered by very specific stimuli, such as a red belly for a stickleback or a silhouette of a hawk for a duckling. It was soon discovered, however, that sticklebacks responded to all novel colors equally, that they exhibited enormous individual differences in responses to the color red (Muckensturm, 1969), and that their aggression readily habituated over repeated trials to the same stimulus object (Peeke, 1969). Essentially the same was found for the releasing capacity of the bird-of-prey shape on the escape behavior of chicks and ducklings (Hirsch, Lindley, & Tolman, 1955). And given some experience, young gallinaceous birds were observed to lose their fear even of a live hawk (Martin & Melvin, 1964). Most important, no neural programs were ever found for innate releasers, and the concept was abandoned. So far, no such programs have been found for the "basic" emotions, either. What might give emotions their specificity are their expressive and subjective correlates.

One cannot foresee or recommend directions for research in emotions for the distant future. The field of emotion research is one of the broadest and richest in psychology. Emotion is implicated in nearly all psychological phenomena—cognition, memory, decision making, motivation, psychopathology, development, and a host of others. Also, emotion implicates nearly all psychological processes that have been studied at the behavioral level (e.g., perception, attention, cognition, learning, recognition, motivation), as well as many neurophysiological processes and structures, many not yet understood. While one cannot foresee the direction of research, one can be certain of important developments given the growing interest in and vigor of the field of the emotions. The next decade will be an exciting one in the study of emotion. Several papers in this issue point to promising directions. Rigorous investigation of emotional processes is leading to increased understanding of a number of basic issues; we are closer than ever to comprehending how the mind and body interrelate.

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