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Affective Science: A Research Agenda

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In the Afterwords following each chapter we highlighted agreements and disagreements about each of the twelve questions. Here we will first consider a few issues that cut across those questions, identifying what we believe to be common ground and providing our own perspective on three issues about which there is divergence. Then, we will take up each of the twelve questions and present some of our ideas about the research that would move the field forward.

While we attempted not to inject our own judgments in the Afterwords, this chapter by necessity has to reflect our own beliefs. The other contributors to this book would likely offer different judgments about what are the major disagreements among researchers worth commenting upon, and many would propose a different research agenda. Here we do not claim to provide the final word; there is no one best view or research agenda, precisely because there are too few data. There is a lot more argument in the responses to the twelve questions than data to argue about. Our goal is for the reader to finish this book thinking about what research on emotion needs to be done. If the reader disagrees with us about what research should be done, and that disagreement serves to stimulate thought about what research the reader wishes to pursue, we will have accomplished our objective.

We did circulate an earlier version of this chapter to five of the contributors, who represent a wide range of viewpoints. While we benefited from their criticisms and made changes in what we have written in response to their suggestions, none of them will agree with all of what we say in this chapter. At this juncture there are many paths for research to follow. The choice of which research path to take reflects judgments about what is (most) important, what is likely to pay off, and what kind of research a person finds most enjoyable to do. Ten years from now, we will better be able to see which paths have been most productive.

What Most Students of Emotion Agree About

We originally did not include the word "most" in the title of this section, but we found, to our surprise, that there is some dissent about some of the points we present in this section.[1] At the least, all scholars and investigators characterize emotion as involving multiple elements, and would endorse most of the elements and functions in the following list.

1. There is information processing and evaluation of events that provoke an emotion. There is divergence about just how to characterize those processes, and to what extent there might be universal features.
2. There are expressive and physiological changes that are to some extent distinctive for each emotion. There is divergence about: (a) whether there is a distinctive signal for every emotion, although nearly all agree that there is a distinctive signal for some emotions; (b) whether there are distinctive changes in autonomic nervous system activity and in central nervous system activity for each emotion; and (c) the extent to which there might be universals in signals or in some of the physiological changes that occur.
3. There is retrieval of relevant memories, expectations, and methods for coping with the emotion-provoking event.
4. Emotion involves a subjective experience, a feeling state, which may include awareness of some or all of these elements. For some theorists, this is the only essential element in emotion; for others, subjective experience is not essential. And some would argue that we may not always be aware of our emotional feelings when we are in the midst of an emotion.

Emotion is not a peripheral phenomenon but involves the organism totally. Emotional experience shapes and reflects individual personality development. Emotion serves a number of functions, although investigators differ in whether they agree with each of the functions listed below or how important they consider any one of these functions to be.

1. Emotions have motivational properties, to the extent to which people seek to maximize the experience of positive emotions and to minimize the experience of negative emotions.
2. Emotions organize behavioral and physiological patterns to deal with emotion-evoking events, interrupting less important ongoing activities. At high-intensity levels, emotions may disorganize behavior and planning.
3. Emotional signals inform others, which is crucial, not only in infancy but throughout life in social interactions.
4. One's emotional experience affects one's well-being and may have implications for one's physical health.

What Students of Emotion Disagree About

- Are emotions best conceptualized in terms of discrete states or dimensions?

Most of those who work from evolutionary viewpoint, examining emotional responses, have postulated a number of discrete emotions, such as anger, fear, disgust, and so forth. Most of those who emphasize cognition, studying the language of emotion or attributions about emotional states, have postulated a set of emotional continua or dimensions, such as pleasant-unpleasant, unaroused-aroused, approach-avoid, and so on. There are exceptions, of course; for example, Lazarus, a cognitive psychologist, postulates discrete emotions, and Davidson, a psychophysiologist, postulates approach--avoidance as a fundamental dimension in distinguishing among emotions.

We see no contradiction between a discrete and dimensional approach to emotion; these two formulations are useful for different purposes. No set of dimensions so far proposed adequately captures the known differences among discrete emotions. Yet many of the emotion dimensions can usefully describe variations in the experience of any particular discrete emotion. Some of the emotion dimensions can also distinguish among the discrete emotions.

An intensity dimension can distinguish variations in the strength of anger episodes, fear episodes, etc. Perhaps also some emotions have a more narrow range of intensity variations than others (e.g., there may be a greater range in the intensity of anger experiences than in the intensity of surprise experiences). A pleasant to unpleasant dimension can distinguish between groups of emotions: anger, fear, disgust, and sadness are unpleasant, while relief, contentment, amusement, and pride are pleasant. The pleasant--unpleasant dimension can describe differences within each group of emotions, although that is less certain. Is anger always more unpleasant than fear? The pleasant-unpleasant dimension should not, however, be used to distinguish different instances of the same emotion. While some fear experiences, for example, are more unpleasant than other fear experiences, those differences might better be captured by the intensity dimension rather than a pleasant-unpleasant dimension. An approach-avoid dimension can also be used to describe different instances of the same emotion (e.g., anger involving approach versus anger involving avoidance), as well as to distinguish among emotions (anger usually involves approach and disgust usually involves avoidance). An active--passive dimension can distinguish among different instances of the same discrete emotion, or among emotions (e.g., there is typically more activity in anger than in sadness).

- How Many Emotions Are There?

This is not a meaningful question to those who take a dimensional approach, and they cite disagreement among discrete emotion researchers about the number of emotions in support of their stance. Among discrete emotion researchers, the answer to the question of how many emotions there are depends on the type of evidence they consider.

There is consistent evidence for pan-cultural facial expressions for five emotions: anger, fear, sadness, enjoyment, and disgust (reviewed in Ekman, 1989; see also counter claim by Russell, 1994, and replies by Ekman, 1994, and Izard, 1994). There is still disagreement about whether there is a pan-cultural signal for surprise, contempt, and shame/guilt. Study of the emotion lexicon suggests roughly the same emotions (i.e., Shaver, Schwartz, Kirson, & O'Connor, 1987), although there is little cross-cultural data. Evidence exists for emotion-specific autonomic nervous system (ANS) activity in the case of anger, fear, disgust, and sadness (Ekman, 1992a; Levenson, 1992;

Levenson, Ekman, Heider, & Friesen, 1992). Although replicated within Western and in a non-Western culture, researchers are still arguing over the evidence (Ortony & Turner, 1990; Tassinary & Cacioppo, 1992; Zajonc & McIntosh, 1992). There is evidence for distinguishing positive from negative affect with EEG-based measures of regional brain activity (Davidson, 1992). There is no information so far about whether it is possible to distinguish among different negative emotions, such as anger, fear, disgust, and sadness, though sadness-based psychopathology (depression) can be distinguished from fear-based psychopathology (phobias) on EEG.

Part of the disagreement about the number of emotions can be resolved by considering emotions not as single unitary states but as families of related affective states (see Ekman, 1992b; Lazarus, 1991; Shaver et al., 1987). Each emotion family shares commonalities in their expression, physiological activity, and in the types of appraisal that call them forth. These shared characteristics within an emotion family should distinguish one emotion family from another. Later in this chapter we discuss research necessary to elucidate the concept of emotion families. Part of the disagreement about how many emotions there are comes also from a failure to distinguish among different affective phenomena (see Chapter 2).

- What is the gold standard for knowing that an emotion has occurred?

Is there a sine qua non for emotion? The answer at this time must be No. The investigator must use multiple methods to study emotion, including, whenever possible, measures of behavior, subjective experience, and physiology.

We believe that researchers should not rely exclusively on self-reports. Too much of what we know about emotion has come from questionnaires in which subjects who are not having an emotion try to remember or imagine what they would be thinking or feeling if they were having an emotion. How people account for their emotions provide important data, but we should not assume that accounts given when not experiencing an emotion are going to closely resemble accounts given during or immediately after an emotional episode, and an account may differ in interesting ways from other sources of information about what transpires during an emotional episode. Quite a separate potential problem is the near exclusive reliance on questionnaires or ratings scales rather than free responses to assess subjective experience.

Emotion talk during an interaction can provide continuous information about how emotion is experienced over time (see Marchitelli & Levenson, 1992). All too often, however, it is not emotion talk but reports on rating scales obtained after an emotional episode or series of episodes that are the primary source of information about subjective experience. Rosenberg and Ekman (1994) have shown that such retrospective self-reports are vulnerable to recency effects (see also Ptacek, Smith, Espe, & Raffety, 1994). The use of a rating dial during an emotion episode (Levenson, Sher, Grossman, Newman, & Newlin, 1980; Sher & Levenson, 1982) can provide online continuous information, but at the cost of limiting the number of emotions that can be considered and at the risk of interfering with the emotional experience. Rosenberg and Ekman (1994) and Levenson and Gottman (1983) and Gottman and Levenson (1985) have used different techniques for obtaining data on subjective experience by having subjects review a videotape of their interaction.

A Research Agenda

- Question 1: Are There Basic Emotions?

We will consider two areas of research: study of a culture that is reported not to have one of the emotions that others claim to be universal, and research to elucidate the concept of emotion families.

Research on "Absent" Emotions The position of social constructionists, such as Averill and Shweder, is bolstered by reports of cultures in which a particular emotion supposedly does not occur. For example, Signe Howell (personal communication, June 1985) said that anger is not present in the cultures she studied. If there truly is no trace of anger, no pattern of behavior when provoked, insulted, or frustrated, no evidence of anger displaced onto other targets, it would directly contradict the position of those who presume emotions to be universal. (See Ekman's, Panksepp's, and Scherer's replies to Question 1.)

The universalists can deal with reports from anthropology about "absent" emotions by presuming that the anthropologist must have missed subtle signs of the emotion, or that the emotion occurs but is not named, or that its manifestations were discouraged early in life. Such a view is buttressed by Levy's (1984) observations that while Tahitians do not either label or recognize sadness, sadness nevertheless was apparent in the behavior of Tahitians. Tahitians, Levy said, show sad expressions and behavior when experiencing a rejection by a loved one, but they interpret their behavior as sickness, not sadness, and do not relate it to the rejection. Unfortunately, there is no film or video record, or any other means, of substantiating Levy's claim.

To determine whether an emotion is truly absent in a culture would require that anthropologists and psychologists collaborate in careful examination of such a culture. Simply having more than one observer, in particular observers who differ in their position on universality, would be a vast improvement over the current state of knowledge which is based almost always on the observations of one person. Video recordings of naturally occurring and experimentally arranged interactions would be crucial to determine whether there is any hint of the absent emotion. Extensive and intensive interviewing to learn how the members of the culture construe social events which in other cultures commonly call forth the absent emotion should be conducted. Study of the early years of life could attempt to determine if socialization involves inhibiting the experience of the absent emotion. Elicitors known to call forth emotions at a very early age in Western cultures, such as the visual cliff for fear and arm restraint for anger, should be used.

The verified identification of cultural settings in which there is no trace of an emotion such as anger or fear, in adults, children, or infants, would require fundamental revisions in the position of many of the contributors to this book: Davidson, Dunn, Ekman, Frijda, Goldsmith, Izard, Kagan, Lazarus, LeDoux, Levenson, Panksepp, and Scherer. The failure to find such evidence should give pause to Averill, Clore, and Schweder. Regrettably, because of intercultural communication, direct and through mass media, the time left to do such research is nearly over.

Elucidating the Concept of Emotion Families The concept of emotion families (see Ekman's reply to Question 1) suggests that each emotion, such as anger, fear, disgust, and so forth, is composed of a group of related states that share certain features (appraisals, expressions, subjective feelings, physiology), and differ on those features from other emotions. Although this is an attractive metaphor, the concept of families is vague and not well based empirically. Ekman has used the metaphor of a theme and variations, which implies a central, core set of features. Rather than a theme and variations, perhaps families should be considered to be composed of siblings all of whom equally well represent that emotion, with no one sibling a better or more central representative of what distinguishes one family from another.

Research on each of the features mentioned here—appraisals, expressions, subjective feelings, and physiology—could help to resolve which metaphor is correct, and whether the concept of an emotion family has utility. Such research requires examination of multiple instances of at least two different emotions, such as anger or fear. Naturalistic observations of the different social occasions in which each emotion occurs would provide information about the commonalities in emotion antecedents. Videotape recordings would allow identification of expressions, speech, and other behaviors that are specific to one or the other emotion. Experimental inductions of each emotion would also be necessary to obtain additional data on the physiology, subjective experience, and information about how the person experiencing the emotion accounts for and explains why the emotion occurred.

Emotion researchers must utilize methodological developments from other areas of the biobehavioral sciences where this form of question has arisen. The issue here is whether different emotions are types or taxons, rather than varying on a dimensional continuum. A type or taxon is a categorical entity, even if it is associated with variations on continuous measures (e.g., heart rate). For example, we know that although the distribution of IQ scores in any large sample is normal, those at the low end include subjects who possess a taxon different from the remainder of the sample. Some of these individuals may have Down's syndrome, one consequence of which is to impair IQ. Thus, even though these subjects fall on the lower tail of a normal distribution, it would not be appropriate to consider all of these subjects as varying along the same dimension. In the same way, two emotions might differ in heart rate or some parameter of brain activity. Rather than assume that such variation is dimensional, we can ask whether the distribution of scores obtained during each of the two emotions is best captured by a taxonomic model or by a continuous, dimensional model.

In the last decade, statistical procedures have been developed to assess taxonicity (see Meehl, 1992, for a discussion). Taxonicity has been a key issue in psychopathology research where investigators have been interested in whether subjects who score at the extremes of a distribution on a certain trait are best regarded as a type or simply on the end of the continuum of a distribution. Where a large sample size is available with scores on a continuously distributed variable (e.g., heart rate) from two or more emotions, it is possible to use these statistical techniques to make inferences about the extent to which the data conform to a discrete (taxon) model or a dimensional one.

• Question 2: How are emotions distinguished from moods, temperament, and other related affective constructs?

Considering how central distinctions among the concepts of emotion, mood, and temperament have been, it is striking how little empirical research has actually been performed on these topics. Most of the commentators on this chapter proposed a relationship between mood and emotion, in which mood somehow alters the probability of emotion. Little is known about the mechanism for such putative effects.

How could we structure our research to answer this vexing question? The first choice is whether or not to preselect subjects on the basis of some mood disposition measure. Although that would seem to be the obvious decision, it is not certain whether people who score high on a mood predisposition measure are always in that mood, and if they are not in that mood during the laboratory session, then there is no way to observe the effects of the mood. The alternative is to bring subjects into the laboratory and assess their mood at that time, selecting only those who report experiencing a specific mood. Such screening is more cumbersome, requiring a larger number of subjects.

The second choice is what measure of mood to use. Should it be something such as the PANAS, which measures only a positive or negative mood, or should it be a measure of more specific negative or positive moods? The answer to this will depend on the question that the research is designed to answer.

The third issue is what tasks to provide that might be sensitive to mood effects. Consider the dynamics of emotional reactivity in response to standardized elicitors. We use the presentation of film clips, for example, to illustrate the various ways in which mood can affect emotional reactivity. Subjects who display high positive mood may experience positive affect earlier in the presentation of the visual stimulus. A second possibility is that such subjects might experience more intense positive emotion, with no differences in the timing of the response. A third possibility is that the positive mood subjects will exhibit a longer persistence of the positive emotion once it is elicited. These indices of rise time, intensity, and persistence can be examined using both behavioral and physiological measures sensitive to emotion. To know whether these relationships between mood and emotion were specific to the particular elicitors that were chosen, it would be important to replicate this basic procedure with other types of emotion elicitors.

Ekman has proposed that one important distinction between emotion and mood is that emotion has distinctive facial expressions, while mood does not. Although little empirical research is actually available to substantiate this claim, no one has yet to identify a facial expression that has been observed in a mood state that is not one of the emotional expressions. Although we think it not likely to be productive, a search for mood-specific facial expressions could be done by bringing subjects into the laboratory who differ in some dimension of mood and then videotape them unobtrusively; their facial behavior could be measured with the Facial Action Coding System (FACS) (Ekman & Friesen, 1978).

Ekman has proposed that mood might be reflected in tonic differences in the muscular activity of the face. This could be checked in similar studies in which EMG is used to measure facial activity in subjects who were known to be in one or another

specific mood. This needs to be done separately from the search for visible facial movement, as described previously, since EMG is likely to inhibit at least some observable facial actions.

Davidson's proposal that mood may bias cognition while emotion may bias action is difficult to approach empirically. However, one testable prediction that follows from this proposal is that mood should result in more cognitive constraint than emotion. This pattern may arise simply as a function of the fact that mood persists while emotion is more phasic. Thus, if a subject is probed on information-processing measures after the induction of an emotion or mood, it may be that whatever emotion is being studied has already dissipated to some extent compared with the pre-task period. In contrast, mood, by at least some commentators' definitions, is likely to persist into the task period and thus influence the information-processing measures more than the emotion would. There are many ways in which these ideas might be tested. One strategy would be to manipulate mood and emotion separately and examine their effect on some information-processing measure. After each manipulation (i.e., one designed to affect primarily mood and one to affect emotion) subjects could then be tested on a task designed to assess automatic allocation of visual attention (using the visual probe, reaction-time technique; see Matthews 1990) to determine if the manipulation of mood results in a more pronounced change in visual attention than the manipulation of emotion. The basic prediction in this study is that the mood manipulation would bias visual attention toward positive stimuli more than the emotion manipulation, despite the fact that the reaction-time measure would occur in closer temporal proximity to the emotion elicitor than to the mood elicitor. One psychological mechanism that might account for this type of effect is that emotion more often than mood has an identifiable object. Since mood is less likely to be directed at a specific object, it may be available to bias general cognitive processing.

- Question 3: What is the function of emotions?

While virtually all theorists of emotion have offered commentaries on the functional significance of emotion, preciously little empirical research has actually been performed on this topic. In part, this is due to ambiguities about what is meant by the term *function*. Here we consider function in terms of what are the immediate changes or consequences that ensue when there is some evidence that an emotion is occurring.

Some of the relevant variables may be difficult to assess in a laboratory. For example, many commentators (see the responses to Question 3) have proposed that one function of emotion is to prime particular action tendencies. However, most laboratory situations place severe constraints on the types of action subjects are permitted to perform. It has therefore been very difficult to study this issue directly; investigators have, for the most part, opted for an easy way out by asking subjects to report on their action tendencies. Just how closely such measures are to actual action is unclear.

One type of research that is critically needed is more naturalistic studies of social interaction, particularly in infants and young children, where both emotion and action can be readily observed. Schoolyard play might be the canonical context for

the conduct of such research. Observations in these settings would permit the examination of whether particular types of action reliably followed the display of certain emotions. The emotions could be inferred on the basis of facial and vocal behavior. If there are a small set of action sequelae for different emotions, then there should be frequent observable pairings of emotional expression, followed by particular types of action. If Clore's analysis is correct, then there should be considerable heterogeneity in the form of actions, but the goal of the action should remain relatively invariant within an emotion class. A coding system for goal orientation of action would have to be developed for this purpose. In studies of adult subjects who are seated in chairs in a laboratory, it is difficult to obtain any real action suitable for measurement.

There is some disagreement among commentators on the extent to which emotion influences cognition. This issue was also considered in the previous question on the relationship between emotion and mood, since one distinction that has been proposed is based on their differing functions with respect to action and cognition. Among the essays written in response to this question, there are two principal views with respect to how emotions influence cognition. One view holds that any such influence is on automatic cognitive operations, while another view suggests that emotions affect more extended appraisals. One of the critical problems in conducting research on this issue has been mentioned in the discussion of Question 2—the difficulty of knowing whether the induced affective change is best conceptualized as an emotion or a mood. What is needed are experiments that induce emotions which are immediately followed by tests of both automatic and controlled processes that are matched on basic content and task difficulty. Any differential effects on one versus the other type of cognitive activity can then be assessed. It may well be that some emotions are more likely to affect one type of process, while other emotions may affect another type of process. While such studies have not yet been performed, there are suggestive data from studies of psychopathology where anxiety has been found to more likely affect automatic processes while depression is more likely to affect controlled processes (see, e.g., Mineka & Sutton, 1992). While anxiety and depression are neither emotions nor moods, the evidence does underscore the potential utility of conducting this type of research with normal affective processes.

A number of the commentators offered suggestions concerning the nature of emotional dysfunction. One prevalent theme mentioned by several writers is the idea that emotion expressed out of context, or prolonged beyond the usual duration, may be dysfunctional. These suggestions underscore the critical need for research on the temporal dynamics of emotional processing. We now have good tools to begin to characterize the time course of different response systems that reflect emotion. The duration of physiological and expressive changes in response to standardized emotion elicitors that are short in duration can be measured to obtain information on the persistence of the affective response following the eliciting stimulus. This type of study will provide new information on the duration of responses in different systems. It is likely that the time constant of affective change will differ across response systems, though the implications of this possibility have not been explicitly considered in discussions of the function of emotion.

Another type of dysfunction that may be the precursor to depression involves the failure to engage a positive event. At least some depression is characterized by a

pervasive lack of interest and inability to experience pleasure. In this case, the dysfunction is not in the prolonged duration of negative affect, but rather the inability to engage the positive affect system. Both behavioral and physiological measures of positive affective response to appropriate incentives can be measured to assess this form of dysfunction.

- Question 4: How is evidence of universals in antecedents of emotion explained?

There is now considerable information from questionnaire studies about the common beliefs within and across cultures about the typical events that precede an emotion (c.f. Boucher & Brandt, 1981; Scherer, Walbott, & Summerfield, 1986). Although very important, we conceive of this information as accounts about emotion antecedents that may only partially represent what actually occurs if we were to examine emotional behavior in situ.

Information from questionnaire studies can provide one basis for specifying where and when we should expect to see specific emotions occur. Based on those findings, naturalistic observation and laboratory inductions could test how often these antecedents do actually evoke one or another emotion. In addition to obtaining observer ratings of emotional behavior, and video records which could later be measured, the people manifesting an emotion should be interviewed, to record their account of what they feel and why they feel it. By that means it would be possible to determine how an account of an antecedent event obtained soon after an emotional episode might differ from accounts about those antecedent events given by people who are not experiencing the emotion. Regardless of the degree of correspondence between these accounts, information about what people feel and what they believe brought about their feelings gathered immediately upon the observational evidence that an emotion is occurring will be invaluable to our understanding.

Diary studies offer another opportunity to learn about the antecedent events that commonly precede emotions. One problem that must be overcome is how to secure rich diary information without having the diary recordings become enormously intrusive. We also need to have studies in which there is both diary and observational data so we can learn about the type of emotional events that are typically not reported or are underrepresented in diaries.

Ekman proposed that often events antecendent to emotion are appraised automatically and therefore often the person is not conscious of the appraisal process. This possibility presents serious difficulties for self-report technology, since the very phenomenon of interest would be inaccessible to the measurement technology. The modern armamentarium of the cognitive scientist includes methods that can be used to make indirect, albeit rigorous inferences about such putative nonconscious cognitive processes. For example, if it is hypothesized that loss is a universal antecedent of sadness, pictures and words could be presented following a sadness induction, with the subjects asked to perform a lexical decision task (for the pictures, the task would be to specify whether a picture could be named by a word). Stimuli that included loss themes could be interspersed with other irrelevant stimuli. The basic prediction in this type of study is that reaction time would be faster to the loss themes following a sadness induction compared with the induction of another emotion.

- Question 5: What are the minimal cognitive prerequisites for emotion?

Let us distinguish the circumstances during which two types of appraisal processes occur. In one circumstance the latency is in milliseconds and the person may not be aware of what set off the emotion until after the emotion is in process. In the second circumstance, the latency is longer, and the person typically is aware of what it is that is setting off an emotion as it begins to gradually unfold. For Ekman (1977), the appraisal in the first circumstance is automatic; in the second, the appraisal is extended.

Although it is probably more of a continuum than a dichotomy, this distinction draws our attention to the fact that emotions can occur without extensive neocortical processing. When emotions occur automatically, the people experiencing the emotion cannot tell us about their appraisal process. They can only tell us how they account for their emotional behavior. Important as such accounts are, their import is to tell us how people describe the processes that occur during and after an emotion episode, not the processes that precede and lead to the emotion. It is only when the emotion is brought about through extended appraisal that we can learn about the cognitive processes by asking people about them.

The first empirical step, we believe, is to learn about the type of events that precede automatically activated emotions as compared to emotions that result from extended appraisal. The chief marker of an emotion resulting from automatic cognitive processes would be very short latency. What are the consistencies in emotions that occur from automatic appraisal? How varied are they? Do they resemble emotions that occur through extended appraisal?

Next, we need to begin to study the nature and characteristics of the automatic appraisal process itself. In the discussion of Question 4, we alluded to modern cognitive science procedures for making inferences about nonconscious processes. We believe that such procedures can be usefully applied to the question of automatic appraisals to determine which cognitive processes have been nonconsciously activated and to characterize their time course. Certain physiological techniques can also be used to make similar inferences (e.g., startle probe and event-related potential procedures).

- Question 6: Is there emotion-specific physiology?

Most of the commentators agree that whatever emotion-specific patterning is present is likely to be found in studies of central nervous activity. While some evidence of emotion-specific patterning in the autonomic nervous system (ANS) that has appeared in the past decade is promising, some of the commentators question the logic of expecting invariant autonomic patterns to mark particular emotions. These commentators maintain that because different instances of the same emotion may lead to different actions, ANS activity, which provides support for action, will not be emotion specific. The contrary view maintains that if specific actions have been adaptive in particular emotional contexts in the history of the species, it is likely that these preparations for action will have been preserved, and therefore emotion-specific ANS activity might be found. This is not simply a matter of debate, however, since there is now some evidence of emotion-specific ANS activity.

The most robust findings, however, have been obtained in response to the Directed Facial Action (DFA) task, where subjects are asked to voluntarily produce specific patterns of facial action. While there is some preliminary evidence (Levenson, Carstenson, Friesen & Ekman, 1991) that the same emotion-specific patterns are found with a very different task, this has yet to be demonstrated for each of the emotions they studied, and has yet to be replicated. Moreover, the DFA, as well as most other laboratory procedures, has been gathered in circumstances in which no action by the subjects is relevant for dealing with the emotions that are aroused.

The obvious next step to further clarify this matter is to examine autonomic patterning with subjects in which an emotion is aroused with several likely actions possible. This can be most easily done with an imagery task in which the same emotional experience is elicited with different action patterns. For example, subjects could be instructed to imagine that someone is trying to harm them and they are feeling afraid and they are trying to (a) flee, (b) hide, or (c) fend off the attacker (Lang [1979] did related work along these lines, but unfortunately included in his instructions some of the very changes in physiology—for example, increased heart rate—which are of interest.) We should note that an imagery task may not provide an adequate test, however, since the subject knows that no action can or will be taken. Nevertheless, it is a reasonable next step in pursuit of this issue.

Great progress has been made in studies of other animals where specific circuits are implicated in certain types of simple emotional learning. This work has clearly underscored the important contributions of the amygdala to emotional behavior. As Davidson has noted, however, there exist several case reports questioning the importance of the role of amygdala in human emotion. What is needed are studies in humans that use neuroimaging procedures with good spatial resolution, such as positron-emission tomography (PET) and functional magnetic resonance imaging (fMRI). These methods provide sufficient resolution to examine the functional activity in the amygdala. Using standardized probes to elicit emotion, including procedures virtually identical to those used in animal studies that have clearly implicated the amygdala, such as fear-potentiated startle (e.g., Davis, Hitchcock, Rosen, 1987) and classical conditioning (e.g., LeDoux, 1992), functional activity in the amygdala can be examined.

Of particular theoretical importance will be the study of different emotions that either belong to the same dimension or represent other dimensions. For example, among negative emotions, both fear and disgust are often associated with a strong withdrawal component, while anger and sadness are not. Certain forms of positive affect involve a strong approach component (e.g., anticipating receiving a desired appetitive stimulus), while other types of positive affect do not involve approach (e.g., the contentment that follows the receipt of a desired goal). It will be important to characterize the functional neuroanatomy of the circuits that track the approach–withdrawal dimensions and those that differentiate among emotions within a dimension.

Panksepp raises the important issue of possible neurochemical differences among emotions. This area has been virtually ignored in the human research literature (though see Depue, Luciana, Arbis, Collins & Leon, in press), although relevant

animal data exist. Recent endocrine studies have discovered changes that occur over very short time spans (e.g., Carnes, Goodman, Lent, 1991). We can take the lead from the type of animal studies summarized by Panksepp and search for evidence of endocrine profiles that might distinguish between certain forms of positive and negative affect. However, studies using conventional sampling strategies have not found differences in HPA activity that differentiate between positive and negative affect, though this question is worth revisiting with more sophisticated sampling techniques.

Another strategy is to conduct studies that involve the administration of certain drugs that change mood or emotion in a laboratory context, while functional neuroanatomic and behavioral measures can be obtained. It would be informative to learn how changes in regional brain function induced by the drug administration are associated with changes in emotional state.

Ideally, studies can be conducted that include autonomic, central (via PET or fMRI), and endocrine measures simultaneously. Only in this way will the interrelation among these response systems be examined. As of this writing, there are virtually no studies in the literature that have looked at central and autonomic measures at the same time.

- Question 7: Can we control our emotions?

There are clearly many different ways in which people control their emotions. They range from avoiding potentially aversive stimuli, to inhibiting the expression of emotion, to using exogenous and endogenous distracters, as well as many other ways. It is also apparent that people engage in strategic maneuvers to increase the frequency and duration of positive affect. For future research on this topic to flourish, researchers will need to begin to specify the mechanism(s) by which control can be established.

It is probably most appropriate to choose a limited number of control strategies and characterize them in more mechanistic terms. For example, one form of control might be to mentally disengage from the emotion. This disengagement process might be similar to the disengage component of attention that has been characterized by Posner and colleagues in their PET studies of attention subcomponents. It may be that the capacity to disengage from an ongoing emotion critically depends on the prefrontal cortex. One characteristic of patients with frontal lobe damage is that they perseverate, though perseveration in emotional domains has not been systematically studied. Emotional perseveration may reflect a deficit in the capacity to disengage from an emotion, once it begins.

To investigate an individual's skill at terminating an emotion once it has been triggered, it would be informative to conduct a study that involved the presentation of a strong emotional stimulus that has been previously found to produce a change in emotion that persists following the offset of the stimulus (certain film clips have this characteristic). Immediately following the offset of the stimulus, subjects would be presented with one of two different cues. One cue would signify that subjects should attempt to terminate the ongoing emotional response, while the second cue would signify that the subject should do nothing. The advantage of presenting these cues

after the termination of the eliciting stimulus is to prevent strategies from occurring that might result in alterations in how the emotional information is initially processed. While such strategic differences during encoding (i.e., alterations in appraisal) are another important form of emotion regulation, they may be different from the sorts of strategies people invoke to manage emotion once it occurs.

Another strategy that is critically needed in the study of emotional control is a developmental approach. As the chapter on development has underscored, one of the most salient changes that occurs with development is the capacity to control emotion. It would be informative to perform both naturalistic and experimental research longitudinally to examine the developmental changes in the capacity to control emotion. These developmental changes could be examined in relation to maturational changes in certain aspects of brain function.

If the prefrontal region is critical for certain forms of emotional control as some have suggested (e.g., Davidson, 1993), it would also be informative to conduct experimental studies on patients with frontal lobe damage to better characterize their deficit in emotional control. Perhaps such patients can take advantage of exogenous cues for emotional control, but fail when the control process depends entirely on endogenous processes.

Finally, once standard procedures are adopted to assess emotional control objectively, it is possible to examine individual differences in this skill. It would be informative to know if such individual differences are associated with systematic differences in patterns of regional brain function.

The most immediate need is for the development of objective paradigms to assess different aspects of emotional control using standardized emotional probes. Levenson and Gross have begun to do this in the context of their work on the inhibition of facial behavior during the presentation of emotional film clips. This approach needs to complemented with procedures that instruct subjects to begin the control strategy after they have received the emotional input to rule out basic differences in perceptual and attentional function during the presentation of the emotional stimulus. Once these assessment tools are developed, they can be applied in a variety of contexts to begin to address questions of mechanism.

- Questions 8 & 9: Can emotions be nonconscious? What is the relation between emotion and memory?

We have combined our comments on these two questions since they are so intimately tied together. To illustrate why these two questions should be addressed together, recall the clinical procedure that Korsakoff used in his interviews with amnesic patients. He would walk into each of his patient's rooms with his hand extended to shake theirs in greeting. Unbeknownst to the patient, Korsakoff would have a thumbtack between his fingers so that he would prick the patient as he shook their hand. When he would revisit the patient's room the next day or several days later, he would first ask the patient who he was. His amnesics were totally unaware of having any previous encounter with him. He would then offer his hand in greeting. His patients would refuse to shake his hand or would grimace when extending their hand toward him. In modern terminology, we would say that the patients had an affective

implicit memory of the unpleasant handshake. However, because of their severe amnesia, they were incapable of explicitly encoding the identity of the doctor and so exhibited the peculiar dissociation between explicit and implicit recognition.

While clinical observations of this sort have been available for quite some time, little systematic research has been performed on this topic. It would be useful to study amnesics with both positive and negative affect elicitors to determine if implicit affective memory is equally robust for information of each valence.

We know very little about the differential characteristics of conscious versus nonconscious emotional memories. Paradigms have been developed that successfully show the acquisition of an unconscious affective memory. Using classical conditioning, Öhman has shown that backwardly masked faces can acquire signal value by pairing with an aversive stimulus, despite the fact that subjects are completely unaware of having seen those faces in the past. In the backward masking procedure, an emotional face is presented briefly and then followed immediately by a neutral face. The phenomenal experience of the subject in this case is that only a neutral face has been presented. If LeDoux is correct in his analysis of the neural substrates of these effects, we would expect that learning the association between the face and the aversive US would depend on the amygdala. If the stimuli were not masked and therefore visible, we would expect subjects to acquire both explicit and implicit information about the stimulus and therefore such learning should include the participation of both the amygdala as well as the hippocampus. These hypotheses could be tested in a study involving each of these conditions during which measures of regional cerebral blood flow are acquired with either PET or fMRI.

We also know little about the relative persistence of implicit affective information. A productive research design might be one that exposed one group of subjects to faces that are backwardly masked and conditioned to an aversive stimulus (producing an unconsciously conditioned emotional response), while another group is exposed to the identical faces in the absence of masking, but conditioned to the same aversive stimulus. A third group might be exposed to the same faces in the absence of any conditioning. Tests of recognition and liking of the faces could then be performed at 6-month intervals to determine if the implicit information persists as long or even longer than the explicit information.

The suggestions here all concern situations in which subjects might be unaware of the stimulus that produces the emotion. Another important form of unconscious affect arises when subjects are unaware of an emotional response they emit—that is, they cannot report on an emotional process that is occurring in themselves. Most individuals have had the experience of interacting with another person and observing subtle changes in the individual's facial expression of emotion of which the expressor appears to be unaware. Researchers who have viewed videotape of interpersonal interaction that is emotionally charged are consistently impressed with the high density of facial and other expressive behavior that occurs over time. In strict information-processing terms, it is unlikely that working memory has sufficient capacity to represent all of the behavior that occurs at any given point, since the density of the outflow is so high in these circumstances.

While such anecdotal observations are common, harnessing the phenomenon in a tractable laboratory paradigm has remained a difficult empirical challenge. One

strategy that might be worth exploring is an interruption paradigm. Two individuals might be engaged in a dyadic interaction that is being monitored (via video) by expert facial coders. When a coder detects what appears to be a particular facial expression displayed by one participant, a signal is given to the target subject and she or he is asked to press one of seven buttons labeled with prototypic facial expressions of emotion. The subject is asked to press the button that most resembles the facial expression he was displaying in the period immediately preceding the signal. Signals can be presented during both expressive periods and control periods when the subject was displaying no visible facial action. Researchers can code the ongoing stream of facial behavior after the fact. The objective coding could then be compared with the subject's responses, and the frequency of unambiguous discrepancies between the objectively coded and subjectively experienced expressive periods could then be determined. There might well be individual differences in the extent to which subjects are aware of their expressive behavior (see, e.g., Weinberger, Schwartz, & Davidson, 1979). Of course, such an interruption strategy may prove unworkable or too costly if subjects, once interrupted, become preoccupied with the likelihood of being interrupted again.

We wish to note one other topic that relates to unconscious emotion and memory that has received almost no research attention—emotion in dreams (see Merritt, Stickgold, Pace-Schott, Williams, & Hobson, 1994, for a recent exception). The little work that has been performed indicates that dream content is often laden with emotion, and yet it is recalled relatively infrequently. We know almost nothing about the extent to which emotion in dreams is consistent within subjects and whether it is associated with patterns of waking emotion and mood. Are differences in post-sleep mood associated with variations in the emotional content of dreams from the preceding night? Can we use physiological measures (e.g., EEG measures of prefrontal asymmetry, as in Davidson, 1992; startle probe measures, as in Lang, Bradley, & Cuthbert, 1990) to obtain unobtrusive indices of at least the predominant valence of dream content? Such physiological measures can be obtained in the laboratory and then related to ratings of the emotional content of dreams elicited by reports following REM awakenings.

- Question 10: How do individuals differ in emotion-related activity?

This is a very active area of research, but it is an area of research that requires large sample sizes, and ideally longitudinal study. Individual differences in emotion should be manifest in the magnitude, latency, and recovery time to return to a baseline state. Research should determine if individual differences cut across or are specific to each of the emotional response systems (physiological, expressive, subjective). We also do not know if individual differences are emotion specific, specific to hedonic grouping (consistent among all negative or among all positive emotions), or are general across all emotions. Crucial, too, is the consistency in individual differences across the life span (see the following discussion under Question 11).

We do not know of research that has determined whether any of the individual differences we have outlined are more or less in evidence with weak, as compared to very intense, emotional provocations. The threshold for evoking any emotional

response at all may itself be another aspect of emotion in which individuals differ. Still another interesting possibility is that the initial moments during an emotional reaction may show less variability across individuals than the subsequent moments as the emotion unfolds and develops.[2]

An individual differences strategy can offer a powerful test of hypotheses about the underlying physiological substrates of emotion. For example, if an investigator hypothesizes that physiological pattern X is specific to a particular discrete emotion or dimension of emotion, then individuals can be measured on physiological pattern X and studied to determine if they differ in the predicted way in their emotional reactivity. A concrete example of the utility of this strategy is the recent work of Davidson on individual differences in prefrontal asymmetry and their relation to emotional reactivity. In a series of studies Davidson and his colleagues (e.g., Tomarken, Davidson, & Henriques, 1990; Wheeler, Davidson, & Tomarken, 1993) have found that subjects with more right-sided prefrontal activation exhibit more intense negative responses to negative emotional stimuli.

- Question 11: What develops in emotional development?

Change in different components of emotion is one of the most salient features of human development across the lifespan. Research on this topic is also one of most demanding because of the problem of developing equivalent elicitors at different ages. For example, one of the questions that several commentators addressed concerned the issue of whether the core experience of an emotion remained invariant across development. To study this issue, researchers would need equivalent elicitors at different ages, for if differences were found in some parameter of emotional experience, a question would immediately arise as to whether the elicitors were really equivalent at the different ages. Different experiences might be produced by different elicitors.

Panksepp proposes that certain changes in affective development are associated with the maturation of specific central nervous system processes. This is a critical issue to investigate in both animal and human studies. However, it is necessary to go beyond mere descriptive correlations between patterns of central nervous system changes and developmental shifts in emotional processing. There are so many changes that occur in parallel in the central nervous system that establishing an association between a change in one component of neural structure or function and emotional development would be woefully inadequate. What is needed are studies that manipulate the brain in a specific way and then observe the effects of the manipulation on the hypothesized component of emotional development. For example, some investigators (e.g., Denenberg & Yutzey 1985; Fox & Davidson, 1984) have suggested that the regulation of negative affect (i.e., its voluntary inhibition) is mediated in part by interhemispheric inhibition of the right hemisphere by the left hemisphere via the corpus callosum. If this is true, individuals with lesions in the corpus callosum should show a specific deficit in this form of inhibition, though other aspects of emotional functioning should be relatively intact. This hypothesis can be examined in animal studies by performing an experimental callosotomy and then observing the animal over the course of development. If this were done in rhesus monkeys, we would expect to see in normal monkeys a period during

which separation protest would peak and then be followed by a more attenuated response. If this diminution in separation protest that is observed with development is mediated in part by interhemispheric inhibitory pathways, lesions of the corpus callosum should disrupt the achievement of this particular developmental milestone. Human infants born with agenesis of the corpus callosum might profitably be followed to examine the same sorts of questions.

There exists considerable disagreement in the field concerning the significance of early facial expressions of emotion (compare Camras and Izard). One view holds that facial expressions of discrete emotions are invariant across the lifespan and provide an accurate read-out of emotional state. The other extreme posits that the same pattern of facial behavior may denote different states since contextual factors are important determinants of the facial configuration at each moment. We need better descriptive data on a larger sample of individuals. It would be informative to know how particular expressions are associated with both antecedent conditions and action sequelae at different ages. For example, we could choose one or two emotional expressions and chart the antecedents and consequences of the same expression at different ages longitudinally. This would provide a needed corpus of data that would be informative regarding the significance of facial expression at different ages.

Another issue in need of additional research attention is the relationship between affective and cognitive developmental milestones. Dunn has argued that the emergence of new emotions during the second and third years of life influences the development of new cognitive skills. It would be interesting to use an age-held-constant design in which children who did versus those who did not exhibit certain emotions (e.g., shame, embarrassment) were studied to determine their proficiency in certain cognitive skills, such as accuracy in anticipating the actions of others. This would be another way to establish the relationship between the acquisition of emotional and cognitive milestones.

- Question 12: What influences the subjective experience of emotion?

We advocate more use of procedures that allow subjects to respond freely to questions about their feelings. Although analysis of free responses is more cumbersome, there are a number of emotion lexicons that can be used to categorize free responses. Since there is no consensus about what set of emotion categories would be most useful, findings should include information not just by category, but must include the specific responses that were categorized. Once a free response is obtained, it may often be useful to ask subjects to give an intensity rating for the emotion they have named. We (Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Ekman, Davidson, & Friesen, 1990; see also, Levenson, Ekman, & Friesen, 1990) use a procedure in which the subject is asked to rate the intensity of the emotion on a nine-point scale, anchored at one end with "No feeling of that emotion" and at the other end with "Most intense experience of that emotion they have ever had." It may also be useful to consider adjusting such intensity ratings on the basis of additional information in which subjects are asked to rate their own most intense experience of each emotion as compared to what they believe is the most intense experience of an emotion that anyone might ever have (see Ekman, in preparation).

Other procedures for calibrating subjects' ratings have also been developed. For example, some subjects use the upper end of the scale more than the lower end, while others show the reverse pattern. In other words, there are systematic biases that people display in their use of such rating scales. Wheeler, Davidson, and Tomarken (1993) have developed a regression-based procedure to remove the variance associated with global rating biases from simple Likert-type scales. They have demonstrated that when such procedures are used, the relation between self-reported emotion and physiology is improved.

It would also be useful to explore the utility of having subjects describe emotional experience in other than verbal terms. Colors, sounds, and other types of visual images could be explored, to determine if there is consensus. No one, for example, has pursued the findings of Clynes (1973) which suggested different patterns of motor activity occurred when subjects were asked to report on different emotions by touching a pressure transducer.

In addition to reports about emotions, it would be useful to also probe the memories and sensations of subjects. See the work of Levenson and Tsai (in preparation), Rime, Philippot, & Cisamolo (1990), and Scherer and Wallbott (1994) for studies of the sensations reported to occur with different emotions.

We need to know how subjects report their subjective experience of each emotion when they are in a baseline state, as compared to how the same subjects report their subjective state during or after an emotional episode. There are a number of techniques for obtaining reports of subjective experience during emotional episodes. Most commonly used is a self-report given immediately after an emotional episode. Even with a brief emotion induction, such as the viewing of a one-minute stimulus film, more than one emotion may occur. Recent evidence (Rosenberg & Ekman, 1994) shows that retrospective reports overrepresent the last emotion felt, not the earlier emotions. Retrospective reports, however, do allow more extensive questioning about the experience without contaminating the experience. Having subjects rate their emotions during an emotional episode deals with the problems of retrospective reports, but at the cost of diminishing the information that can be obtained. It is probably not feasible to have subjects rate more than the intensity of positive and negative emotion, or one or two specific emotions. And even then, the rating task itself may interfere with the emotional experience. Another procedure is to have subjects view the interaction in which their emotions occurred (Levenson & Gottman, 1983) or the film that evoked the emotion (Rosenberg & Ekman, 1994), providing information about the emotions they remember having felt initially. Gottman and Levenson (1985) have obtained continuous ratings using a joystick in the viewing task, but have only recorded emotions as positive or negative. Rosenberg and Ekman had their subjects stop the stimulus film whenever they remembered having felt an emotion; at that point, the subject provided a differentiated close-ended report of specific emotions.

With any of these techniques for reporting emotion, it would be important to determine which components of the emotion package (facial expressions, vocalizations, central and peripheral physiology) are most correlated with subjective experience. This may not be the same across emotions, across techniques for sampling emotions, across development, across individuals, or across cultures.

Conclusions

We adopted the phrase "affective science" because we believe emotions cannot be fully understood unless we also understand the other affective phenomena which border on emotion. We need to elucidate how emotions differ from moods, from preferences, from emotional traits, and emotional disorders. And understanding of each of these phenomena requires research that will to a large extent use the same methods.

We believe that programmatic research is required on each of the fundamental questions we have raised in this book if we are to see substantial progress. Methods are now available for instigating emotion in a number of different ways, and for measuring many different aspects of emotional experience. While questionnaires will undoubtedly always be part of the research enterprise in affective science, we hope to see less exclusive reliance upon them, and more use of observational methods and psychobiological assays. The examination of multiple emotions, each evoked more than one way, with comparisons to naturally occurring instances, at different points in the life span, are all needed. By definition, such work will require collaborations among investigators, from different subspecialties within psychology and to some extent also between psychologists and colleagues in other disciplines (e.g., linguistics, sociology, anthropology, neuroscience, psychiatry, zoology, among others).

Just as the study of cognition provided a unifying theme for psychology in the 1970s, we believe that emotion can serve a similar role in the 1990s. Emotion is relevant to many branches of psychology, including clinical, developmental, social, personality, comparative, and cognitive psychology as well as behavioral neuroscience. It has the potential to tie different areas together and to foster interdisciplinary bridges. In an era when the discipline of psychology is becoming increasingly fractionated, the prospect of a more integrated approach that takes into account different levels of analysis is appealing. Emotion is a topic that holds out such a promise.

There is a new generation of investigators just now or recently trained, and a lifetime of research to be done in affective science. Questions about the nature of emotion will be with us for a long time, but we hope there will be decisive data on some of the fundamental questions posed in this book within the next decade. Arguments about how best to interpret those data will probably remain with us for a long time.

Notes

1. This section is based on an earlier manuscript prepared by Paul Ekman with input from Richard Davidson, Robert Levenson, and Klaus Scherer.
2. Jack Block made this suggestion.