and perhaps even atavistic, are the concerns that give events their emotional signifi-
cance. It is difficult to find an advantage for many attachments or likings. Neverthe-
less, many nonfunctional or even dysfunctional emotions and emotional phenomena
occur. They can largely be understood as consequences of a functional provision
when operating under taxing circumstances and at the limits of its resources, and on
occasion manifesting a functionally appropriate lack of selectivity in its operation.
Part of the dysfunctional aspects probably are consequences of breakdowns or
malfunctions in emotion-controlling processes.

Human Emotion: A Functional View

ROBERT W. LEVENSON

Emotions are short-lived psychological-physiological phenomena that represent effi-
cient modes of adaptation to changing environmental demands. Psychologically,
emotions alter attention, shift certain behaviors upward in response hierarchies, and
activate relevant associative networks in memory. Physiologically, emotions rapidly
organize the responses of different biological systems including facial expression,
muscular tonus, voice, autonomic nervous system activity, and endocrine activity to
produce a bodily milieu that is optimal for effective response. Emotions serve to
establish our position vis-à-vis our environment, pulling us toward certain people,
objects, actions, and ideas, and pushing us away from others. Emotions also function
as a repository for innate and learned influences, possessing certain invariant fea-
tures along with others that show considerable variation across individuals, groups,
and cultures.

In my response to this question, I will briefly discuss these functions, with an
implicit emphasis on emotions that occur when a person's physical and psychological
well-being are at stake.

Intrapersonal Functions

Coordination of Response Systems

The essential function of emotion is organization. It has been widely observed that an
emotional response includes manifestations in subjective experience, behavior, and
physiology. The subjective aspect includes the phenomenological experience of the
emotion, perceived physical sensations, and associated memories. The behavioral
aspect includes facial expressions, posture, and voice tone. The physiological aspect

includes the autonomic, somatic, central nervous systems as well as endocrine responses. Often an emotional episode occurs without warning and lasts for less than a minute. Given this lack of opportunity for preparation and this brevity, the amount of coordination and organization that is required to mount a unified and effective response is considerable. The complexity of this task of coordination is especially imposing because each of the component subjective, behavioral, and physiological systems has its own control mechanisms, and is capable of quite independent action.

Shifting Behavioral Hierarchies

Emotions have the capacity to activate certain behaviors, which might normally exist at the bottom of behavioral hierarchies. Thus, under the proper conditions, anger can drive the pacifist to fight; sadness can make the strong weep; and fear can cause the brave to cower. In this regard, emotion has the unique capacity to set aside, in a moment, a lifetime of individualized learning, refinement, culture, and style, revealing the common denominator of human response.

Recruitment of Physiological Support

Behaviors such as withdrawal, expulsion, fighting, fleeing, and nurturing each make different physiological demands. A most important function of emotion is to create the optimal physiological milieu to support the particular behavior that is called forth. Given that this milieu includes the central, somatic, and autonomic nervous systems, each with a number of important subsystems, and the importance of rapidity of response, the ability of emotion to choreograph the activity of these diverse systems has profound implications for our capacity to adapt and survive.

Short-circuiting Cognitive Processing

Evolution has endowed humans with exquisite cognitive powers, which provide myriad possibilities of action and inaction for responding to environmental challenges. Emotion is the antidote to the problems caused by this embarrassment of riches. Hearkening back to an earlier stage of phylogenetic development, emotions provide us with access to a limited number of simpler time-tested modes of efficient, effective adaptation.

Although rational thought and emotion are often depicted as locked in an eternal battle, there is typically more cooperation than strife. Nonetheless, any functional view of emotion must allow for the possibility that emotion and rational thought can sometimes work at cross-purposes. In those instances, and especially when the challenge to personal well-being and integrity is strongest, the more primitive emotion system often gains the upper hand. Clearly there are times when action is more appropriate than deliberation, when responding is more appropriate than considering, when doing is more appropriate than planning. In situations where hesitation could have the most dire of consequences, emotion functions to set aside cognitive processing that is too cumbersome, too obsessive, too self-indulgent, and, ultimately, too likely to be inconclusive.

Interpersonal Functions

Communication and Control

The expressive characteristics of emotion in voice, face, gesture, and posture serve an important function in communicating our emotional state to others. The value of these signals is twofold: first, by allowing others to know how we feel, and second, by influencing their behavior. The power of simple emotional signals to mobilize others can be seen quite vividly when fear expressed by one person causes a crowd to panic. At a more intimate level, the crying of an adult or a child powerfully calls forth nurturing behaviors on the part of others; a shared smile can defuse the most dangerous situation and can create an instant bonding among strangers.
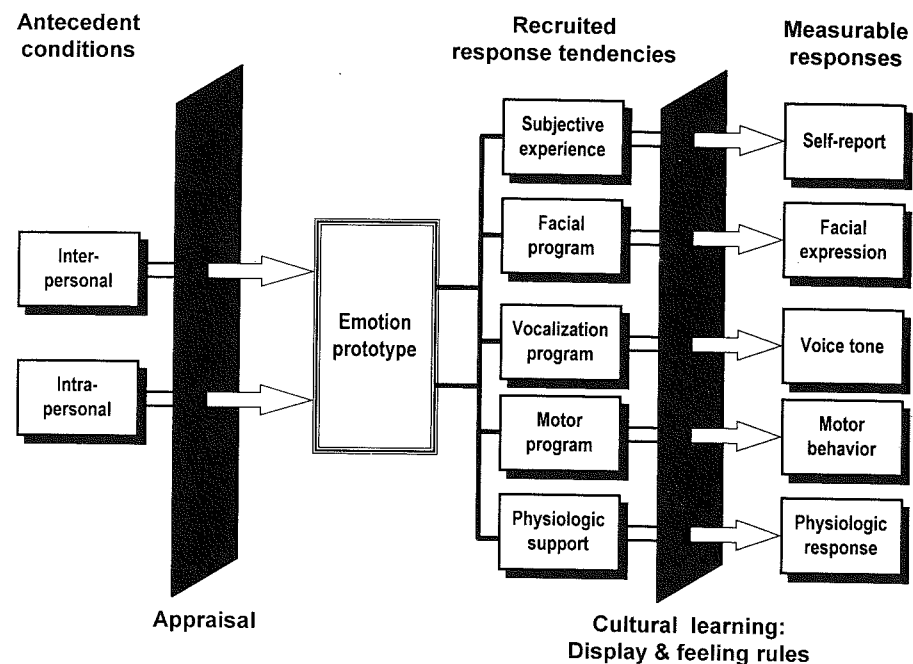
Establishing Our Position in Relation to Other People, Ideas, and Objects

Emotion also functions to establish the spacing between us and the entities that populate our personal worlds. Acting via ubiquitous processes of approach and avoidance, emotions draw us toward some things and push us away from others. In this way emotion functions to establish and structure those things that define us as individuals. These include our social networks of friends and enemies (and all the gradients in between), our likes and dislikes (forming the basis for our aesthetic sensibilities), and our moral sense of what is right and what is wrong.

Repository for Influences of Evolution, Learning, and Culture

I embrace a biocultural model of emotion, which reflects a confluence between innate and learned influences. My elaboration of this model is depicted in the following figure[1]. As suggested by the figure, emotions arise from a transaction between the organism and its internal and external environment. Antecedent conditions, which may be *inter*personal or *intra*personal, are perceived and processed by an appraisal system that imbues them with meaning in terms of the organism's well-being, plans, and goals. Certain outcomes of this appraisal process evoke an emotion prototype, which recruits response tendencies in multiple systems encompassing subjective experience, behavior, and physiology. The configuration of these response tendencies represents a generalized solution for coping with the demands of the original antecedent condition. However, these response tendencies do not directly lead to measurable and observable emotional responses. Rather, they are acted on and often transformed by cultural learning, resulting in the emotional responses that can be observed by conspecifics and measured in the laboratory.

In this model, innate hard-wired influences are found in the connections between the emotion prototype and the recruited response tendencies (indicated by solid connecting lines in the figure). The primary loci of cultural influences are seen in the two shaded panels labeled "appraisal" and "cultural learning." In the realm of *appraisal*, culture greatly influences the sense we make of and the meaning we

Antecedent conditions | **Recruited response tendencies** | **Measurable responses**

Inter-personal, Intra-personal → Emotion prototype → Subjective experience → Self-report; Facial program → Facial expression; Vocalization program → Voice tone; Motor program → Motor behavior; Physiologic support → Physiologic response

Appraisal

Cultural learning: Display & feeling rules

ascribe to our experiences. In the realm of *cultural learning*, display rules (e.g., Ekman & Friesen, 1969) influence the ways we visibly express our emotions, and *feeling rules* (e.g., Hochschild, 1979) influence how we experience and label our emotions.

Conclusion

As this brief overview should make clear, emotions serve an impressively large number of highly critical functions for individuals, groups, and cultures. A defining feature of the human condition, emotions serve as one of the major pathways along which both innate and learned influences are expressed.

Note

1. A number of theorists have offered models that include both hard-wired and learned influences, including those attributable to culture (e.g., Ekman, 1972, 1984; Heider, 1991b; Lazarus, 1991; Levy, 1973; Mesquita & Frijda, 1992).

Emotion Serves to Decouple Stimulus and Response

KLAUS R. SCHERER

One of the most exciting leads for answering this question is Donald Hebb's early but rarely cited assertion that man is the most emotional of all animals (Hebb, 1949). He based this claim on his observation of the frequency and complexity of emotional behavior in many different species of animals, and reached the conclusion that the degree of emotionality seems to be correlated with the phylogenetic development of sophisticated central nervous systems. Hebb explained the paradox that the most rational primate, man, is also considered the most emotional by pointing to the effect of sociocultural control mechanisms that mask the high level of human emotionality (see Elias, 1977).

If one accepts Hebb's claim (i.e., increasing potential for complex emotional behavior as one moves from fairly simple to more advanced species), one can attempt to identify which of the more sophisticated behaviors in the advanced species seem to benefit from an emotion mechanism. This may shed some light on the evolution of emotion. As one moves up the evolutionary scale, the following features appear to become more prominent: the ability to process more complex stimulus patterns in the environment, the simultaneous existence of a multitude of motivational tendencies, a highly flexible behavioral repertoire, and social interaction as the basis of social organization. Emotion seems to be centrally involved in determining the behavioral reaction to environmental, often social, events of major significance for the needs and goals of the organism.

I have used the analogy of emotion as an *interface* to refer to this mediation between environmental input and behavioral output. Since there are nonemotional reactions to environmental stimulation, other interfaces must also exist (e.g., reflexes or rational problem-solving). However, the special role of emotion seems to be that of an intelligent interface that mediates between input and output on the basis of what is most important to the organism at a particular time. It evaluates incoming information on the basis of a situationally weighted assessment of an event's relevance to central needs or goals and prepares appropriate adaptive action. Because of this strong tie to motivation, Tomkins (1984) has considered emotions as amplifiers of

The Search for Autonomic Specificity

ROBERT W. LEVENSON

Ask a group of people to define "emotion" and most will include some form of physiological activity in their definition. Test the phenomenological limits, remove one feature at a time, query as to whether what is left is still "emotion," and, for many, physiological activity will be revealed as *a* necessary (or perhaps *the* necessary) condition for emotion. Then ask this group whether the same physiological changes occur when they are angry as when they are happy, when they are sad as when they are disgusted, and almost all will say no. There is a belief in the general population in emotion-specific physiological activity, and small wonder. Specificity in the physiology of emotion is manifest in many observable ways. Crying (an activity mediated by the parasympathetic branch of the autonomic nervous system) is often seen when people are sad, sometimes when they are happy, but almost never when they are angry or disgusted. We have sensations of warmth (which are mediated primarily by the sympathetic branch of the autonomic nervous system) when we are angry, sometimes when we are happy, but almost never when we are afraid. Our very language bespeaks a belief in emotion-specific physiological activity, especially in the metaphors we use to describe our feelings. We use metaphors of pressure (e.g., blowing your top) and heat (e.g., blood boiling) when we talk about our anger (Lakoff, 1987; Kovecses, 1989), but rarely, if ever, when we talk about other emotions such as sadness, disgust, or happiness. Of course, all this folk wisdom and linguistic convention do not establish the existence of emotion-specific physiology, but it is suggestive.

The Autonomic Nervous System and Emotion

In examining the current state of our knowledge in this area, I will be limiting my comments to the question of emotion-specific activity in the autonomic nervous system, a physiological system intimately tied to emotion.

The autonomic nervous system is a complex and highly differentiated constituent of human physiology. Among its many functions, two stand out. First, there is its regulatory function, operating to maintain a stable and consistent internal bodily milieu. This role as the "guardian" of homeostasis is the function most often emphasized in textbook accounts. The second important function of the autonomic nervous system is to provide support for behavioral demands; this role as the "disrupter" of homeostasis is arguably the function that is most relevant to emotion and most readily accommodates the notion of emotion-specific physiology.

Viewed in light of this second function, the argument for emotion-specific autonomic activity is a simple one. If the primary purpose of emotion is to organize efficiently and rapidly the organismic response to changing environmental demands, and if part of that response is the mobilization of appropriate adaptive behavior, then one would expect that some activation of the autonomic nervous system would be necessary to support that behavior. Whether or not this autonomic response is reliably different for different emotions depends on the answer to two different questions: first, whether or not the different emotions reliably call forth different patterns of behavior, and, second, whether or not these different behaviors require different configurations of autonomic support.

The first question can be exemplified by asking whether patterns of behaviors such as "fighting" and "shutting out" are equally likely to be called forth by all emotions or more likely to be called forth by some emotions than others. The equiprobability notion seems inconceivable to me; "fighting" is much more likely to be called forth in anger, while "shutting out" is much more likely to be called forth in disgust. Neither behavior pattern seems very likely to be called forth in happiness or sadness. The second question can be exemplified by asking whether a behavior such as "fighting" requires the same kind of autonomic support as does a behavior such as "shutting out." Again the notion of autonomic sameness seems farfetched.

Completing the logic of this functional analysis, if certain emotions are most closely allied with certain behavior patterns, and if different behaviors require different kinds of autonomic support, then there is a basis for some amount of emotion-specific autonomic activity. Assuming that the need for rapid mobilization is such that assemblage of the physiological support must be initiated before the behavior is fully manifest, it should be possible to find evidence of emotion-specific autonomic activity in the laboratory even under conditions in which the prototypical behavior never actually occurs. Thus, autonomic changes conducive to fighting should be seen during anger even if the subject never actually engages in fighting.[1]

Difficulties in Studying Emotion-Specific Autonomic Nervous System Activity

Studying emotion-specific autonomic nervous system in the laboratory is rife with problems—some soluble, others almost intractable (Levenson, 1988). Difficulties begin when we attempt to produce emotion. Ethical considerations place limits on the kinds of elicitors that can be used and, as a result, most emotional stimuli used in the laboratory do not produce very intense emotions. Further, many laboratory stimuli

produce multiple emotions (either in blends or in sequences); this greatly complicates the task of studying the physiology of single emotions.

Other problems are inherent in the very nature of emotion and the autonomic nervous system. Most emotions are brief, and thus it is easy to miss them. While retrospection may have some cachet in the realm of self-report, it has little validity in the realm of physiology; if the autonomic activity associated with a brief emotional episode is not recorded when it occurs, it is forever lost. Temporal matching between emotion and the associated autonomic nervous system activity is crucial. The autonomic nervous system is not the exclusive servant to emotion, it is constantly responding to other metabolic demands, homeostatic needs, and certain cognitive and perceptual processes. One must extract from this flux those moments when the autonomic nervous system is acting primarily in the service of emotion. In the study of emotion-specific autonomic activity, those moments are the signal; all else is noise. Furthermore, within the autonomic nervous system, different functions (e.g., vascular constriction, sweat gland activity) have different latencies of onset, different durations of action, and different courses of offset, thus further complicating the temporal matching with emotion.

Individual variation presents challenges as well. A stimulus that produces disgust in 99 subjects might amuse the hundredth. Thus, care must be taken to determine which emotion or emotions, if any, were produced in each subject. Subjects may also have individual response stereotypies, which are idiosyncratic patterns of autonomic nervous system response (e.g., some may have highly reactive cardiovascular systems, others might have highly reactive sweat glands). Subjects come to the laboratory with very different attitudes and underlying moods. A subject's skepticism and irritation at having to be in an experiment could have a profound influence on his or her autonomic responses to an experimental stimulus designed to produce a positive emotional state.

And finally there are thorny methodological problems inherent in establishing baselines (subjects rarely, if ever, aren't feeling anything) and analyzing data (e.g., Do group averages have any meaning? How does one strike a balance between Type I and Type II error when measuring a large number of physiological functions during a large number of emotions?).

Autonomic Distinctions Among Emotions

Many dubious propositions are bandied about regarding autonomic distinctions among emotions. Perhaps most improbable is the notion that *every* emotion is autonomically different. It seems far more likely that reliable autonomic differences will only be found between emotions for which the associated prototypical behaviors are quite different. And even among that smaller set of emotions so defined, it is quite unlikely that each of them will be autonomically *unique*, sharing no features in common. Autonomic uniqueness is doubtful because quite different behaviors can make quite similar demands on certain elements of the autonomic nervous system. For example, both fighting and fleeing are likely to require increases in the blood supply to the muscles. Thus, we would expect that anger and fear—which are

arguably associated respectively with these two behaviors—would both be characterized by autonomic activity that increases the availability of oxygenated blood (e.g., increases in heart rate, or in stroke volume). Of course, the muscles that are involved in fighting and those involved in fleeing are somewhat different; thus we would expect that anger and fear would be autonomically different in terms of the patterns of vasodilation and vasoconstriction that regulate the flow of blood to different muscle groups.

For the past 10 years, I have been involved in a series of studies of autonomic differences among emotions. In most of this work we have studied four negative emotions (anger, disgust, fear, sadness), one positive emotion (happiness), and the emotion of surprise. We think we have identified a small number of fairly reliable autonomic differences among the four negative emotions. We have also found some differences between the negative emotions as a group and the positive emotion of happiness.

In this research we have elicited emotions in several different ways. Most of our published work has utilized two eliciting tasks (Ekman, Levenson, & Friesen, 1983): (a) *directed facial action task*—subjects are instructed and coached to contract certain facial muscles to produce facial configurations that are morphologically identical to prototypical emotional facial expressions; and (b) *relived emotions task*—subjects recall and relive emotional memories. Most recently, we have begun studying autonomic differences among emotions that have been elicited by films or that occur spontaneously during the interactions of couples in intimate relationships.

Autonomic Differences Among Negative Emotions

We believe we have identified four reliable differences among the negative emotions of anger, disgust, fear, and sadness and have preliminary evidence for a possible fifth.

These are: (a) anger produces a larger increase in heart rate than disgust; (b) fear produces a larger increase in heart rate than disgust; (c) sadness produces a larger increase in heart rate than disgust; and (d) anger produces a larger increase in finger temperature than fear (Levenson, Ekman, & Friesen, 1990). The possible fifth difference is that sadness produces greater peripheral vascular dilation and greater speeding of blood to the periphery than the other negative emotions (Levenson, Ekman, Heider, & Friesen, 1992).

We have been able to demonstrate that these differences show consistency across subject populations differing in *profession* (actors and students: Levenson, Ekman, & Friesen, 1990); *age* (young subjects and subjects aged 71 to 90: Levenson, Carstensen, Friesen, & Ekman, 1991); *culture* (Americans and Minangkabau males living in West Sumatra, Indonesia: Levenson, Ekman, Heider, & Friesen, 1992); and *gender* (Levenson et al., 1990, 1991). We have also found that these differences show consistency across two *modes of emotion elicitation* (directed facial actions and relived emotions: Levenson et al., 1991), and that they are consistent with findings reported by a number of other investigators using the same and other methods (Levenson, 1992).

Interestingly, these found differences are fairly consistent with hypothetical functional models of autonomic change in emotion insofar as emotions such as fear

and anger, which are thought to be associated with high activity/high metabolic demand behaviors such as fleeing and fighting, are more productive of autonomic changes that would be supportive of these behaviors (e.g., increased heart rate) than an emotion such as disgust, which is associated with low activity/low metabolic demand behaviors. Associations of heat with anger and coolness with fear, which are often found in the metaphorical language used to describe our feelings, are also supported by found differences in peripheral temperature between these two emotions.

Autonomic Differences Between Negative and Positive Emotions

We spent most of our early efforts focusing on differences among negative emotions because we considered them to be most interesting theoretically and to pose the strongest test for emotion-specific autonomic nervous system activity. Thus, our work with positive emotions advanced more slowly. Currently, our best evidence is for four autonomic differences between negative and positive emotions: (a) anger produces larger heart rate accelerations than happiness: (b) fear produces larger heart rate accelerations than happiness; (c) fear produces larger skin conductance increases than happiness; and (d) disgust produces larger skin conductance increases than happiness.

Our earlier work may have been hampered by using a very broad category of happiness. We are currently studying two varieties of happiness—amusement and contentment—and hope to determine whether the differences between the negative and positive emotions are the same for both.

Positive Emotions as Autonomic "Undoers"

One other reason we have not expended as much effort studying autonomic differences involving positive emotions is that there is reason to suspect that such differences might not exist. In an earlier paper (Levenson, 1988), I speculated that positive emotions might not be associated with specific patterns of autonomic activation because they were not associated with behavioral adaptations that required much in the way of autonomic support. Thus, emotions such as contentment might not be associated with any particular pattern of behavior, or if they are, it would be behavior characterized by low activity, which would make little metabolic demand on the autonomic nervous system. Instead of having distinctive autonomic signatures, I proposed that positive emotions might be associated with a state of physiological quiescence, and that their primary function might be to "undo" the autonomic activation produced by negative emotions. In this model, the function of certain positive emotions would be to restore the organism to its pre-arousal state in a more efficient and rapid manner than would be the case if the negative emotions were allowed to run their natural course.

Recently, we reported our first experimental test of this model (Fredrickson & Levenson, 1992). In this study, we induced fear in our subjects using a film stimulus and then determined whether the autonomic arousal associated with that fear would dissipate more quickly if they watched a film known to induce contentment than if

they viewed films known to induce sadness or neutral affect. Results indicated that the cardiovascular arousal associated with fear did in fact dissipate more quickly when it was followed by the contentment film than by the sad or neutral films. Thus, the notion of positive affect as an efficient autonomic "*undoer*" received some preliminary support. This matter is far from settled, however, and we are continuing to work on this phenomenon.

Conclusion

I believe there is now sufficient empirical evidence to reject the notion that all emotions are autonomically the same. The available evidence lends some support to notions prevalent in folk beliefs about emotion, to hypothetical functional models of autonomic changes in emotion, and to physiological metaphors found in the language we use to describe our feelings. Whether the autonomic differences among emotions are limited to those found so far or whether others will also be revealed; whether the differences found so far will generalize to additional modes of emotion elicitation; and the viability of the notion that the positive emotions function as autonomic "undoers" all await further research. Although I think it extremely unlikely that we will find that *most* emotions are autonomically distinguishable, I believe we will continue to find support for the notion that *some* emotions can be reliably distinguished on the basis of their autonomic characteristics.

Note

1. Asserting emotion-specific autonomic activity on the basis of physiological support for behavioral prototypes is just one of several possible functional arguments. A similar case for autonomic specificity could be built on the basis of communicative signals in emotion such as crying, sweating, piloerection, flushing of the face, blushing, pupil dilation, and blanching. Given that each of these signals is produced by action of the autonomic nervous system, emotion-specific autonomic activity is implicated to the extent that these signals are associated with different emotions (e.g., crying associated primarily with sadness, blanching associated primarily with fear).

is little evidence. However, a plausible neuroscenario involves the amygdala, particularly the lateral/basolateral nuclei. As described, the lateral nucleus is the sensory and cognitive port of entry to the amygdala. The lateral nucleus then projects to the basal nucleus. The basal nucleus has several projections of interest: central amygdala; striatum, including nucleus accumbens; neocortical association areas; hippocampal formation. The projection to the central amygdala appears to be involved in the expression of Type I responses and the other projections may contribute to Type II responses. The direct projection to the nucleus accumbens, as described, appears to be involved in some instrumental responses. Inputs to the neocortex and hippocampus may also enter into this. The outcome of emotional evaluation may be routed to the neocortex and hippocampus and from these areas back to the striatum, allowing very complex processing functions and circuits to participate in instrumental behavior that is emitted as a result of the evaluation of stimulus meaning by the amygdala and expressed through the striatum.

In this scheme, the emotional reaction may have both voluntary and involuntary components. To the extent that the emotional stimulus is one that the species has developed specific response strategies to cope with, the initial reaction will be automatic and involuntary and the secondary reaction will be voluntary. In contrast, in novel situations, where species-typical reactions are not available or appropriate, voluntary control may be required; involuntary responses may also occur in the form of displacement activities. To be effective, voluntary responses must be based on information about the stimulus, the situation, and possible outcomes of actions. By necessity, this kind of processing will utilize much of the cognitive capacities of the organism and involve the polymodal and supramodal association areas of the cortex. Involuntary, hard-wired responses eliminate the need for decision. They provide tried and true patterns that tend to work effectively in certain situations and can be executed with much less circuitry. Far too little is known about the interrelationship between Type I and Type II circuitry at this point and we can only speculate as to how the brain generates the integrated emotional response in a given situation.

Emotional Control: Variation and Consequences

ROBERT W. LEVENSON

Emotional control is quite ubiquitous. It is intertwined with the widest range of human activities spanning normal and abnormal development: maintenance of the social order; cultural convention; interpersonal bonding, power, and influence; optimization of performance, and processes of health and illness. A great deal has been written on the psychological and physiological consequences of inhibiting the free flow of emotion—many of which are depicted as dire and unhealthy.

Varieties of Emotional Control

Emotional control can take many forms, which differ in terms of *direction* of control (amplifying, inhibiting); *number* of emotions controlled (single emotions, multiple emotions in blends or sequences); nature of the *transformation* (altering intensity levels of emotions, substituting emotions for other emotions, masking emotions with other emotions); *locus* of attempted control (antecedent conditions, subjective experience, expressive behavior, physiology); *volition* (voluntary or involuntary); *awareness* (conscious or unconscious); *onset* of control (prior to emotion, following emotion); and *target* of control (our own emotions, those of others). Expanding this matrix produces myriad possible forms, delineating a large research agenda if emotional control is to be fully understood.

To study emotional control successfully in the laboratory, we must identify simple, ecologically valid models. For present purposes, I will focus on a very common form of emotional control: suppression—the conscious voluntary inhibition of expressive behavior beginning prior to the event that produces the emotion and continuing throughout that event. Life is replete with occasions for this kind of emotional control—situations in which we are motivated to inhibit the signs that would reveal how we are feeling. We try not to cry when we are hurt by bullies. We try not to laugh at pompous speeches, funerals, and the discomfort of others. We try not to let others see our fear when doing so would risk engendering their

disapproval or inviting them to harm us. We try to hide our anger when it is directed at people we love. We dampen our contempt so as not to hurt or enrage others. We hold back our disgust when confronted with the ravages of illness and injury, or when a friend proudly serves us a special dish that revolts us.

I will also focus on one particular consequence of this kind of suppression—its effect on the autonomic nervous system. The question, simply stated, is: When one is emotionally aroused, does voluntary inhibition of expressive behavior *increase*, *decrease*, or have *no effect* on the level of autonomic activation? This question goes to the core of the relation between expression and physiology in emotion.

What Do We Know About Expression and Physiology in Emotion, and How Much Is Relevant to Emotional Suppression?

As it turns out, we know a great deal about the relation between expression and physiology in emotion; however, almost none of what we know is directly relevant to emotional suppression as I have defined it.

Empirical studies of the relation between expression and physiology can be divided into two paradigms: (1) *studies of dispositional expressivity* and (2) *studies of manipulated expressivity*.

Dispositional Expressivity

In studies of dispositional expressivity, aspects of the emotion response are examined in individuals who differ in how emotionally expressive they typically are. Research in both the "internalizer-externalizer" tradition (Buck, 1979; Field & Walden, 1982; Funkenstein, King, & Drolette, 1954; Jones, 1935, 1950, 1960; Notarius & Levenson, 1979) and in the "repressive coping style" literature (e.g., Levenson & Mades, 1980; Weinberger, Schwartz, & Davidson, 1979) support the conclusion that people who are characteristically unexpressive are *more* physiologically reactive than those who are characteristically expressive.

Does this mean that the effect of emotional suppression is to increase levels of physiological arousal? This is the precisely the conclusion that is often drawn, evoking metaphors of "hydraulic," or "cathartic" models. Unfortunately, such a conclusion is simply not justified. Dispositional studies of this sort do not establish whether emotional expression is actually being *suppressed*. To assert that a person who does not show a great deal of facial expression is actually inhibiting that expression is a wholly unjustified leap of logic.[2]

Manipulated Expressivity

In studies of manipulated expressivity, subjects are led to control their emotional expression and the effects of this control on other aspects of emotion are examined. A number of different experimental paradigms have been used in this sizable literature, with the two major variants involving either having subjects voluntarily construct emotional facial expressions or having them exaggerate or diminish naturally occur-

ring facial expressions. In a recent review of 21 studies in this literature, we (Gross & Levenson, 1993) concluded that with only four exceptions, these studies all failed to provide a direct test of the physiological effects of emotional suppression because they: (1) did not arouse emotion in some way independent of the facial manipulation; (2) did not have subjects inhibit expression at all; or (3) did not measure physiology. Among the four exceptions,[3] the general finding was that inhibiting expressive behavior led to *lower* levels of physiological response.

New Studies of Emotional Suppression

We recently initiated a series of studies using a methodology that we believe will yield more definitive data regarding the effects of suppression. In designing these experiments, we rejected three assumptions that have been tacit in much of the existing work. *First*, we did not assume that the effects of suppression would be the same for all emotions; *second*, we did not assume that the effects of suppression would be the same for all aspects of emotion; and *third*, we did not assume that the physiological effects of suppression would await the start of the emotion-eliciting event. Thus, we planned to examine the effects of suppressing several different emotions; we measured the effects of suppression on subjective experience, expressive behavior, and physiology; and we measured physiology before and during the emotion-eliciting event.

Our experimental paradigm was simple. In the "no-suppression" condition, subjects were told that they would be seeing a short film; in the "suppression" condition, they were told that they would be seeing a short film and they should behave so that a person watching them would not know that they were feeling anything.

Studies of the Suppression of Disgust

Our first two studies were identical expect for the gender of subjects—the first conducted with males, and the second, a year later, conducted with females (Gross & Levenson, 1993). The stimulus film used in these studies portrayed a surgical amputation of a limb, which we had established as a reliable elicitor of both the subjective experience and facial expressions of disgust.[4]

Expressive Behavior. Subjects were clearly able to reduce the visible signs of the emotions they were feeling, as indicated by less overall facial movement and less disgust expressive behavior in the suppression condition than in the no-suppression condition. However, subjects could not *totally eliminate* all expressive signs of disgust. Furthermore, there was some "leakage" to another part of the face; suppression was accompanied by an increase in the rate of blinking.

Subjective Experience. Inhibiting the facial signs of emotion had *no effect* on the intensity of the subjective experience of disgust.

Autonomic and Somatic Physiology. When subjects inhibited the visible signs of emotion, they also reduced their overall level of body movement (both as coded by

observers and measured by a motion sensor). Along with this reduction in bodily movement was a slowing of heart rate. This is consistent with the oft-observed coupling between somatic and cardiac activity, which is primarily mediated by the parasympathetic branch of the autonomic nervous system (Obrist, 1981). Thus far, the effects of suppression could be characterized as a *lowering* of the level of physiological activation, a finding comparable to the conclusions drawn from the four previous studies that we considered as adequate tests of the physiological effects of suppression.

However, elsewhere in the body, the effects of suppression involved a *heightening* of the level of activation. This was manifest in greater constriction of the peripheral vasculature, more pronounced shortening in the time it took the pulse pressure wave to travel from the heart to the finger (a sign that arterial blood pressure had risen), and greater electrodermal activity (i.e., increased skin conductance).[5] All these changes are consistent with the notion that suppression produces *heightened* activation of the sympathetic branch of the autonomic nervous system.

Sex Differences. There were no sex differences in the effects of suppression. Men are often said to control their emotions more than women, but, based on these findings, the effects of suppression, when it does occurs, appear to be the same regardless of the sex of the suppressor.

Temporal Course of Suppression. Most studies of emotional inhibition have only examined the responses that occur during the emotional stimulus. We were also interested in the *preparation* for suppression. Examining the period after subjects were told that they would be asked to inhibit visible signs of emotion, but before the film actually started, revealed that two signs of sympathetic nervous system activation—increased constriction of the peripheral vasculature and increased sweat gland activity—actually began appearing *prior* to the start of the film.

"Stonewalling": A Possible Naturalistic Analog of Suppression?

John Gottman and I have long been interested in the tendency of husbands to withdraw emotionally from conflictive marital interactions (Levenson & Gottman, 1985; Gottman & Levenson, 1988; see also Christensen & Heavey, 1990). Recently, we conducted an investigation of a particular variant of this behavior, which we termed "stonewalling" (Gottman & Levenson, 1993), that occurs when a spouse is subjectively experiencing negative emotion, but provides none of the behavioral signs that usually accompany those feelings. Examining the laboratory interactions of 79 married couples who were trying to resolve a marital conflict, we identified incidents on the basis of observational coding of the following behaviors: (1) no vocal or nonvocal backchannels—these are behaviors such as saying "uh huh" and head-nodding, which, when present, convey to the speaker that the listener is attending; (2) no facial movement; and (3) not looking at the speaker. We found that these behaviors were associated with: (1) highly negative subjective emotional experience; (2) low levels of bodily movement; and (3) high levels of electrodermal activity. Although

husbands were more likely to stonewall than wives, the physiological effects of stonewalling were the same for husbands and wives.

I would argue that stonewalling is an interpersonal variant of emotional suppression. When spouses feel emotionally negative, inhibit facial movements, and reduce overall bodily movement, they are spontaneously producing a state much like the state we produced experimentally in our suppression studies. And, as with subjects in those studies who were asked to inhibit their expressive behavior, stonewalling spouses showed increased levels of sweat gland activity, an autonomic function thought to indicate behavioral inhibition (Fowles, 1980).

Emotional Control: Implications and Consequences

Our studies of suppression and stonewalling (and related research by others) indicate that people are quite adept at inhibiting the behavioral signs of emotion. Although they might not be able to do so completely (especially when the emotion is strong), and although there might be some "leakage" into other behavioral signs (e.g., blinking), the reduction in visible manifestations of emotion can be quite dramatic.

Our studies suggest that reducing the visible signs of emotion is *not* an effective way to reduce the subjective experience of emotion. In our suppression studies, the feelings elicited by the emotion-eliciting films were undiminished in the suppression condition; in our study of marital interaction, stonewallers continued to report feeling quite negative.

In our studies of suppression of emotional response to a disgust-eliciting film, we have found the physiological sequelae of suppression to consist of two quite different kinds of autonomic effects. First, there is a *reduction* in somatic activity and an attendant *reduction* in heart rate, which we believe is parasympathetically mediated. Second, there is an *increase* in vasoconstriction, an *increase* in the rate of blood flow to the periphery, and an *increase* in sweat gland activity, all indicating heightened sympathetic nervous system arousal. These findings point to the limitations of models of emotional inhibition that focus exclusively on increased sympathetic nervous activity (e.g., the model proposed by Cacioppo et al., 1992).

Why Is There Both Parasympathetic and Sympathetic Nervous System Activation During Suppression?

I have already indicated that we believe that the slowing of heart rate associated with emotional suppression is a parasympathetically mediated consequence of the reduction in somatic activity manifest by subjects in the suppression condition. But why, in the face of reduced somatic activity and its attendant decrease in metabolic demand, are there such clear signs of sympathetic nervous system arousal in other cardiac, vascular, and electrodermal systems?

One possible explanation is that the emotion that is being suppressed continues to recruit the same kinds of sympathetic nervous system support that it would if it were fully manifest. I do not believe this the case.[6]

Instead, I believe a more viable explanation for this sympathetic nervous system activation is that inhibiting the visible signs of emotion involves real work, and that this work makes significant metabolic demands. As I indicated in my answer to Question 4, emotions call forth powerful motor programs that mobilize activity in the muscles of the face, the trunk, the limbs, and other parts of the body. These motor programs enable the organism to adapt rapidly to the environmental demands that provoked the emotion. To eliminate the visible signs of emotion, emotional suppression likely mobilizes "bracing" and "braking" actions that attempt to hold these emerging somatic aspects of emotion in check. Thus, the observed heightened sympathetic activation (in sweat gland activity, pulse velocity, and vasoconstriction) is an indicator that such inhibitory work is being done. That some of these sympathetic nervous system changes occur *prior* to the commencement of the emotional stimulus, lends further credence to this "bracing" explanation.

Implications for Health

There is nothing inherently unhealthy about activating the autonomic nervous system. Physical exercise produces high levels of autonomic nervous system activity, and these are thought to be health-promoting. This begs the question of why emotion, which can also produce high levels of autonomic nervous system activity, would not also be health-promoting?

I would argue that there is little reason to suspect that the autonomic activity associated with emotion has any untoward health outcomes *except* when one or both of the following two conditions are met: (1) autonomic arousal is sustained and chronic; and (2) autonomic arousal exceeds metabolic demand.

Chronic autonomic reactivity has historically assumed a prominent role in etiological models that link psychosocial and emotional factors with early disease processes and with disease onset (e.g., Holroyd & Gorkin, 1983; Jemmott & Locke, 1984; Krantz & Manuck, 1984; MacDougall, Dembroski, & Krantz, 1981; Miller, 1978; Obrist, 1981; Steptoe, 1981). Recent studies of the effects of social stress on the development of atherosclerosis in monkeys (Kaplan, Pettersson, Manuck, & Olsson, 1991) provide strong experimental support for these notions.

As for the second condition, the notion of "physiological arousal in excess of metabolic demand" is a powerful explanatory construct. When people are running or engaged in other forms of aerobic exercise, a metabolic demand is created that is appropriate for the level of increased cardiovascular activity engendered by these activities. If this same level of cardiovascular arousal were produced when the person was relaxed and sitting still, then the arousal would be in excess of the metabolic demand. Similarly, when we *act* in the service of our emotions, the "motor programs" (Frijda, 1986) that are associated with different emotions create a level of metabolic demand that is appropriate for the level of arousal. If our emotions are aroused along with their attendant autonomic activation, and we do *not* act—because of some voluntary inhibition (as in suppression or stonewalling), some external restraining circumstance, or some involuntary, characterological or pathological inhibition—then there will *not* be a level of metabolic demand that is sufficient to accommodate the heightened physiological arousal.

The damaging effects of physiological arousal in excess of metabolic demands can be illustrated by simple analogy. Assume an old garden hose has several places where the rubber has become thin and brittle. No matter how high the water pressure, the hose will continue to function without damage as long as water is removed as powerfully from the distal end as it is pumped into the proximal end. If, however, the pumping force becomes greater than the extracting force, reflecting that less water is needed than is being pumped or that the hose has become blocked, the chances for the hose rupturing at one of its weak spots increases. And the likelihood of damage under these conditions is greatly increased the longer and the more often the water is turned on.

This crude hydraulic analogy notwithstanding, is there any evidence that chronic emotional inhibition is actually associated with negative health outcomes? One line of inquiry that is relevant to these issues suggests that behavioral inhibition (operationalized as not disclosing traumatic events) can have unfavorable effects on immune system functioning and on physical health (Pennebaker & Beall, 1986; Pennebaker, Hughes, & O'Heeron, 1987; Pennebaker, Kiecolt-Glaser, & Glaser, 1988a, 1988b). Although in no way settling this issue, these findings are certainly provocative, suggesting that certain kinds of emotional inhibition may well have adverse health consequences.

Notes

1. My response to this question draws on the work of James J. Gross, a doctoral student in my laboratory with whom I have been working collaboratively in the area of emotional control.

2. Cacioppo, Uchino, Crites, Snydersmith, Smith, Berntson, and Lang (1992) offer similar criticisms of the failure of such studies to actually test the "hydraulic" model. They then offer an alternative model based on dispositional differences in the "gain" of physiological and expressive channels. Unfortunately, they have not yet provided an empirical test of their model, or of the alternatives they criticize.

3. The exceptions involved suppression of expressive responses to electric shock (Colby, Lanzetta, & Kleck, 1977; Lanzetta, Cartwright-Smith, & Kleck, 1976); amusing films (Bush, Barr, McHugo, & Lanzetta, 1989); and pleasant and unpleasant films (Zuckerman, Klorman, Larrance, & Spiegel, 1981).

4. For his dissertation, Gross has recently completed another study using the same paradigm to examine inhibition of the visible signs of emotion with film stimuli known to elicit two other emotions: amusement and sadness, and a film known to elicit a neutral affective state. The results of this study should help answer the very important question of whether the effects of emotional suppression are consistent across emotions.

5. In Fowles' (1980) adaptation of Gray's two-factor learning theory, increased electrodermal activity is viewed as indicating activation of the "behavioral inhibition system." We consider emotional suppression as operationalized in this study to involve a form of behavioral inhibition.

6. A critical test of this explanation will be provided by our studies of the suppression of emotions other than disgust. Assuming some degree of emotion-specific autonomic nervous system activity (as I have posited in answer to Question 6), then if the suppressed emotion continues to recruit its characteristic pattern of autonomic nervous system activity, we would expect the physiological effects of suppression to be different for such emotions as disgust and sadness.