Arne Öhman

Making sense of emotion: evolution, reason & the brain

We often define the basic goals of human striving in terms of emotion: we yearn for happiness and do our utmost to avoid misery.[1] But making the distinction between positive and negative emotions is not as simple as saying that we seek the former and shun the latter. Emotions often have a will of their own and may resist attempts to be disciplined. Victims of wartime atrocities and natural disasters, for example, may unwillingly suffer from involuntary flashbacks in which they re-experience the trauma, eliciting intense fright that threatens or undermines adjustment. But some individuals – such as journalists, photographers, and Peace Corps workers – are willfully drawn to those very fear-ridden circumstances, not to mention people who find their (sometimes compulsive) joy in activities most of us fear – parachute jumping, mountain climbing, or extreme skiing. Likewise, our lives may become devastated by the prototypical emotion we all desire, passionate love, and we may ruin our health with the delights of food and drink. Still, for most of us, life without emotion would not be worth living. But at the same time, others have regarded emotion as a dark, alien force to which we helplessly succumb, to our own detriment.

Clearly, emotions resist simple interpretation. The purpose of this essay is to discuss the conflicting nature of emotion in light of modern research in psychology and neuroscience. I start with some philosophical considerations that lead to a conceptualization of emotion that ties emotion to the body via evolutionary biology and neuroscience. I then review how contemporary science has addressed some of the classic questions of emotion research.

The conflict-ridden nature of emotion has been evident throughout recorded intellectual history. Almost 2,500 years

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1 This essay was completed while the author was a Fellow at the Center for Advanced Study in the Behavioral Sciences in Stanford, California.

ago, at the birth of Greek philosophy, Demokritos said that we need wisdom to cure the mind of emotion the way we need medicine to cure bodily ailments.[2] This idea was central to the Epicurean and Stoic philosophical movements, which predicated their notions of the good life on the insight that we are disturbed not by things themselves but by what we make of them. Reason tells us that we need not fear death because we shall not be there to experience it. We should enjoy food, drink, and intellectual exchange in the context of cultivating friendship. But we should not let emotions associated with insatiable desires for ephemeral things – such as wealth, fame, and power – seduce us. In contrast, the early Christians did not trust the power of reason to control emotion, but made a handful of problematic emotions central to the deadly sins (the committing of which did make death something to fear): avarice, lust, envy, gluttony, indifference, pride, and wrath.

The Stoics made an interesting distinction – between the first and second 'movements' of an emotion. The first movement is reflexive, such as when we instinctively duck for a swooping bird or stop dead when confronted by a snake. The second movement is what we make of this instinctive response: How dangerous is the situation? Will the bird attack again? Is the snake poisonous? This process of evaluation depends on voluntary mental activity. For example, after the initial surge of erotic excitement upon encountering an overwhelmingly attractive potential partner, one might then rationally analyze the situation, which may result in emotional deactivation by shifting one's attention to something less evocative. By making the second movement the essence of emotion, the Stoics changed the meaning of emotion from an automatic and involuntary response to something individuals could consciously control and take responsibility for.

The enigmatic nature of emotion may be one reason science has long neglected it. But there are other reasons as well. The way we normally know emotions is through feelings, which are elusive, capricious, and probably changed by the very act of observing them. Above all, they are observable only in the mind's eye of the emoter. Feelings, therefore, elude science, which aspires for an objective database in which observers can agree on raw data accessible to many observers. Accordingly, some have argued that the subjective nature of feelings excludes them from the realm of science.

However, few deny that they have feelings, and therefore a science of emotion remains incomplete without them. As Jeffrey Gray pointed out, feelings are the raw data of emotion for each of us, which we can use to test theories of emotion in our own mind.[3] Of course, such an exercise does not constitute a science, but it may help achieve one of the goals of science – helping people to understand the world in which they live.

Indeed, emotions *are* observable by an outsider, but only if we reject the notion of feelings as *the* raw data of emotion. The uniquely human ability of language provides a means for people to make their feelings known to the outside world, even though putting words to emotional experience poses challenges

2 This part on the history of emotion is very much inspired by Keith Oatley, *Emotions: A Brief History* (Malden, Mass.: Blackwell Publishing, 2005).

3 Jeffrey Gray, "The Content of Consciousness: A Neuropsychological Conjecture," *Behavioral and Brain Sciences* 18 (1995): 659–722.

for the verbal community. As behaviorist pioneers Edward C. Tolman and B. F. Skinner pointed out, language describing emotion is necessarily less precise than language depicting the outside world. Since an object or event in the world is available both to the language learner and the supervising verbal community, the community can reinforce the correct naming of objects and their characteristics. On the other hand, when trying to teach children to talk about their emotions, the verbal community can only interpret a child's body language as indicating fear rather than anger, for instance. Nevertheless, in the end, adults are reasonably good at labeling the emotion they feel, sometimes to the point of providing meaningful quantitative estimates of its intensity.

Evolutionary theory, in contending that humans have specifically evolved the capacity to sense the emotions of others, points to an even stronger argument for the possibility of objectively observing emotion. Evolutionary scientists commonly assume that the pressure of complex social organization catalyzed the rapid enlargement of the human brain during the last million years. Robinson Crusoe, as Nicholas Humphrey once remarked, illustrates this model of human evolution: the real challenge for Crusoe was not to survive alone on the island, but came with man Friday.[4] (Had Monday, Tuesday, Wednesday, and Thursday made their presence known as well, Crusoe really would have been put to the test.) Successful social navigation demanded not only that individuals could recognize many group members but also accurately decode their emotional states, in order to understand, predict, and exploit their actions. One could even claim that we have a special organ that allows (and sometimes impedes) emotion recognition: the face. Darwin himself provided a compelling argument that a primary function of the face is to communicate emotion. Indeed, a substantial research body attests to the fact that humans from diverse cultures are quite adept at distinguishing a set of apparently universal emotions from facial expressions.[5]

We have more than the movement of facial muscles to help us discern the emotional state of a fellow human. In a very real sense, emotions reside in the body, since they mobilize the body's metabolic resources for potentially vigorous action. Many of us have noticed the racing heart, the dry mouth, the cold sweat, and the 'butterflies in the stomach' in anticipation of a fearful encounter. These bodily changes are controlled by the autonomic nervous system, which is primarily responsible for matching metabolic resources to the muscular – and, to some extent, the mental – needs of the body.

Subtler physiological changes indicative of emotion, of which even the emoter may not be consciously aware, may also be readily apparent to observers. A blushing face reveals embarrassment; an opponent's pupils widened in fear can inspire confidence in a combatant; a date's pupil size can also help a person gauge the progress of his seductive efforts. Whereas some physiological changes, such as blushing, are specific to a particular emotion, the majority of them, like pupil size, indicates some unspecific emotional activation. In any case, physiological changes of this type

4 Nicholas Humphrey, *Consciousness Regained: Chapters in the Development of Mind* (Oxford: Oxford University Press, 1983).

5 Paul Ekman, *Emotions Revealed* (New York: Times Books, Henry Holt & Co., 2004).

are relatively easy to measure. In fact, an interdisciplinary field called psychophysiology[6] has developed a body of knowledge recording and interpreting peripheral bodily changes to psychologically meaningful stimuli, including emotional events.[7] Thus, psychophysiology provides one avenue for making emotions objects for scientific scrutiny.

Actions are another good indicator of emotion, since an important function of emotion is to prime and add urgency to action.[8] Thus, we can infer emotion from different aspects of action, both expressive and instrumental. As we have seen, we can detect and interpret emotion from facial responses, the primary example of expressive behavior. But emotion can also charge instrumental action by giving value to stimuli: what we like we will approach, what we dislike we will avoid.[9] We can observe this approach-avoidance dimension at many levels. For example, gaze direction is informative because we tend to look at things we like and avert our eyes from things that we dislike. General posture also gives clues to emotion; fear creates a tense posture, revealing an obvious readiness to escape. Then there is gross locomotion, which modulates the distance between ourselves and surrounding objects (including people). Some approach-avoidance is subtle, such as when we read new e-mails instead of answering the disturbing ones in our folders denoted 'urgent.'

Finally, we are often also aware of the stimulus situation eliciting an emotion, which provides abundant cues for likely emotional reactions and thus places useful constraints on the interpretation of bodily and behavioral responses as well.

In concert, all of these different domains of observation help supply an objective delineation of emotion accessible to scientific study. Furthermore, we can correlate these domains with neural events in brain imaging studies, thus advancing our understanding of the brain mechanisms of emotion.

Connecting emotion to different outputs – verbal reports as well as physiological and behavioral changes – does more than merely provide an operational definition of emotion. It provides a conceptual perspective on emotion that is easy to integrate with psychobiological considerations, which incorporate both evolutionary theory and neuroscience.

First, this scheme stands in opposition to the common notion of an emotion as a unified entity that is isomorphic with the felt emotion. Rather, felt emotion is one of several ways in which an emotion may manifest itself; an emotion is actually a complex reaction composed of several loosely coupled response components, none of which is necessary or sufficient to infer the emotion.[10] This

6 John Cacioppo, Lou Tassinary, and Gary G. Berntson, eds., *Handbook of Psychophysiology* (New York: Cambridge University Press, 2000).

7 Arne Öhman and Stefan Wiens, "On the Automaticity of Autonomic Responses in Emotion: An Evolutionary Perspective," in *Handbook of Affective Sciences*, ed. R. Davidson, K. Scherer, and H. Hill (New York: Oxford University Press, 2003), 256–275.

8 Nico Frijda, *The Emotions* (Cambridge: Cambridge University Press, 1986).

9 P. J. Lang, M. M. Bradley, and B. N. Cuthbert, "Emotion, Attention, and the Startle Reflex," *Psychological Review* 97 (1990): 377–398.

10 P. J. Lang, "Anxiety: Toward a Psychophysiological Definition," in *Psychiatric Diagnosis: Exploration of Biological Predictors*, ed. H. S. Akiskal and W. L. Webb (New York: Spectrum, 1978).

approach sees emotions as fuzzy concepts, best defined in terms of the degree of overlap with a prototype of a full-blown emotion, which includes an emotional stimulus, a reported feeling, a facial expression, psychophysiological activation, and emotional behavior.[11]

Second, this approach establishes behavioral and psychophysiological links between human and animal emotion, paving the way for an evolutionary analysis of emotion. Because evolutionary analyses center on adaptive function, they offer an interesting perspective on the long-standing belief that emotion undermines wisdom. If we think that cultivating wisdom is the uniquely human approach to bettering our position in the world, then it follows that natural selection must have favored human reasoning ability, and if so, emotion must have assisted, rather than undermined, wisdom. Indeed, a phenomenon as ubiquitous in mammalian life as emotion simply must have an important function; otherwise it would not have survived the natural selection process.

Yet, historically, psychology has been skeptical about emotion not only because of its subjective nature, but because of its questionable functional status as well. In fact, some investigators surmised that the primary effect of emotion was to disorganize behavior. But while we have all been pressed by overwhelming emotion to act stupidly, emotion would not have evolved had disorganizing behavior been its primary function. It would have been unlikely in animals as well, remaining a curious human ability with the obscure purpose of undermining higher cognition.

11 P. Shaver, J. Schwartz, D. Kirson, and C. O'Connor, "Emotion Knowledge: Further Exploration of a Prototype Approach," *Journal of Personality and Social Psychology* 52 (1987): 1061–1086.

Using neuropsychological data on the effect of frontal-lobe lesion, Antonio Damasio built a strong case that emotions are critical to humans and human cognition.[12] Persons with lesions in the ventromedial prefrontal cortex (at the bottom of the frontal brain, just above the nasal cavity) show few obvious deficits (as revealed by psychological tests) in functions like perception, attention, memory, and language. Nonetheless, their lives fall apart. Even individuals who functioned at a high level before the lesion destroy their circumstances through a series of ill-advised economic and social decisions.

Damasio reasoned that their decision making had become dissociated from their emotions, which normally serve as "biasing devices" that assist in making decisions. When we are faced with a decision, positive associations (conscious or unconscious) surrounding some choices make them seem more appealing, while negative emotions surrounding others make them more or less impossible to choose. The ventromedial prefrontal cortex provides the interface between the cognitive and the emotional brain by evaluating "somatic markers" that convey information about emotion-related bodily changes. In the absence of the emotional backdrop provided by these somatic markers, the person with a lesion in the ventromedial prefrontal cortex is likely to get stuck pondering a multitude of alternatives, eventually making a bad choice.

This proposal fits into a broader perspective that views emotions as helping establish priorities for action.[13] Significant events in our world elicit different

12 A. R. Damasio, *Descartes' Error: Emotion, Reason, and the Human Brain* (New York: G. P. Putnam, 1994).

13 Frijda, *The Emotions*.

emotions, and these emotions guide action by highlighting important goals. An approach-avoidance dimension pervades the neural organization controlling goals and their emotional valence.[14] Some goals are negatively defined – that is, they are avoided because they are related to pain, fear, and loss – and others are positively defined because they activate powerful appetitive motivational states.

Evolution has equipped our brains with a system that is activated when we reach valued goals. It extends from the midbrain through the central parts of the brain, which control basic life functions, to the frontal cortex; it is served by dopamine neurons; and it modulates neural activity in large parts of the brain. It is activated by food and water, sexual activity and orgasm, defeating a rival, collecting resources, and so on.[15] Importantly, the neurons of this system are easily conditioned to fire to stimuli that signal reward.[16] It is this system that produces the kick we feel when reaching a goal ("Yeah, I did it, didn't I!"). It is also a system that can be co-opted by chemicals to produce addiction. In fact, all known addictive substances act at various receptor sites of the reward system.[17]

From an evolutionary point of view, this system is a clever device to make organisms honor goals vital to survival and procreation. Thus, we can see emotions as grounded in evolutionarily defined systems – i.e., reward, defense – which make us want to do what our forefathers had to do in order to make sure that their genes were represented in the next generation.[18]

This evolutionary analysis provides an explanation for one aspect of the inherently conflictual nature of emotions alluded to in the opening of this essay: at least the basic emotions operate according to an evolutionary agenda that may differ from our culturally defined agenda. The evolutionary agenda wants, above all, for genes to be propagated; therefore, the central task for humans (and other animals) is to mate, procreate, and take care of offspring. Hence, even though his Victorian imprinting precluded an explicit statement, Darwin would have agreed with Freud that sex is the most powerful source of motivation, bound to generate conflicts within and between the sexes, and within any group of people. Other emotionally charged basic motives that can produce conflict include dominance as well as competition for, and the hoarding of, resources.

From this perspective, an important priority for any culture is to domesticate emotions that are likely to generate conflicts and threaten group cohesion. An essential component of socialization, therefore, is to acquire the ability to regulate emotion. As a result, the success-

14 Lang et al., "Emotion, Attention, and the Startle Reflex," 377 – 398.

15 Trevor Robbins and Barry Everitt, "Motivation and Reward," in L. Squire et al., eds., *Fundamental Neuroscience*, 2nd ed. (San Diego: Academic Press, 2003).

16 W. Schultz, "Multiple Reward Signals in the Brain," *Nature Reviews Neuroscience* 1 (2000): 199 – 207.

17 George Koob, "Drug Reward and Addiction," in Squire et al., eds., *Fundamental Neuroscience*.

18 Arne Öhman, Anders Flykt, and Daniel Lundqvist, "Unconscious Emotion: Evolutionary Perspectives, Psychophysiological Data, and Neuropsychological Mechanisms," in *The Cognitive Neuroscience of Emotion*, ed. R. Lane and L. Nadel (New York: Oxford University Press, 2000), 296 – 327.

fully socialized individual has a cultural self with goals that may differ from (but are likely to be less evocative than) the goals of the evolutionary agenda. Thus, as philosophers realized long ago, we are more or less designed to get stuck on the horn of the dilemma between (culturally defined) reason and emotion.

The modern science of emotion has revived the Stoic distinction between a first and a second movement of emotion. The research literature has extensively documented the first, reflexive motion in particular. Here, Robert Zajonc's pioneering work demonstrated the "mere exposure effect."[19] In this critical experiment, participants were exposed to a set of Chinese ideograms very briefly – so briefly that they could not distinguish the ideograms. They were then shown and asked to rate the stimuli they had already viewed as well as stimuli to which they had not been exposed. Participants rated the previously exposed Chinese ideograms as more likable than similar nonexposed control ideograms.

Joseph LeDoux provided a potential neural underpinning for this effect by demonstrating that stimuli could reach the amygdala, a collection of nuclei in the temporal lobe and the hub of the brain's emotional network, by a direct and fast "low road" that did not pass through the cortex.[20] Through his work with animals, LeDoux argued that this direct route to the amygdala enabled rapid activation of defense in threatening situations.

Making sense of emotion

LeDoux's work showed that emotions could be activated without fully processing the stimulus in the sensory cortices. Consequently, because evolution has been likely to retain this functional organization, it should be possible to evoke emotions in a person even if he or she is unaware of the stimulus. Studies using masking techniques to conceal an emotional stimulus have confirmed this supposition. In these studies, an emotionally evocative stimulus, such as a picture of a snake for individuals who are intensely afraid of snakes, is presented for hundredths of a second and then immediately masked by another stimulus. The experimental subject perceives only the masking stimulus consciously, remaining unaware of the preceding target stimulus. Psychophysiological recordings demonstrate that individuals specifically afraid of snakes show larger responses to the stimuli masking snakes than to the stiumuli masking spiders, and vice versa for individuals specifically afraid of spiders.[21]

Furthermore, humans spontaneously imitate emotional facial expressions (as assessed by electrophysiological measurements). Experimenters using masking stimuli have observed an unconscious imitation response to both angry and happy faces.[22] Without knowing it, we respond to miniscule facial gestures,

19 W. Kunst-Wilson and R. Zajonc, "Affective Discrimination of Stimuli That Cannot Be Recognized," *Science* 207 (1980): 557 – 558; R. Zajonc, "Exposure Effects," in *Feelings and Emotions: The Amsterdam Symposium*, ed. A. Manstead, N. Frijda, and A. Fischer (Cambridge: Cambridge University Press, 2004), 194 – 203.

20 Joseph LeDoux, *The Emotional Brain* (New York: Simon and Schuster, 1996).

21 A. Öhman and J. Soares, "'Unconscious Anxiety': Phobic Responses to Masked Stimuli," *Journal of Abnormal Psychology* 103 (1994): 231 – 240.

22 U. Dimberg, M. Thunberg, and K. Elmehed, "Unconscious Facial Reactions to Emotional Facial Expressions," *Psychological Science* 11 (2000): 86 – 89.

which add emotional color to our social interactions. Whether we feel relaxed or uncomfortable with some people may thus depend on nonconscious emotional cues. This implicit level of emotional give-and-take – which lies hidden behind explicit intentions, interpretations, and verbal statements – plays an important role in determining the outcome of human encounters. In addition, it is open to conditioning: when a mild electric shock to the fingers followed the presentation of a masked angry face, participants subsequently exhibited an elevated physiological response to the angry face when it was presented without the masking stimulus.[23] These findings imply that we not only respond emotionally to stimuli of which we are unaware, but we may also come to imbue such stimuli with a negative emotional valence through nonconscious conditioning.

These studies using peripheral physiological indices of emotion are supplemented by brain-imaging studies.[24] Consistent with the "low road" notion, these brain-imaging studies show that the nonconscious activation of the amygdala by emotional stimuli takes a subcortical route. For example, the amygdala can be activated by visual stimuli presented in a blind cortical field, that is, a lesioned part of the visual cortex that gives rise to blindness in the corresponding visual field.[25]

Essentially, the research reviewed here gives substance to the Stoic conception of a 'first movement' of emotion, which is automatic and reflexive in nature but can still respond to quite complex stimuli. This automatic emotional activation sets the stage for further emotional processing. In a sense, these data demonstrate that emotions are in the body before they are in the mind.

Damasio's somatic-marker hypothesis revives a central idea in the history of emotion, which was independently formulated more than a hundred years ago by Carl Lange, a Danish physiologist, and William James, the famous American philosopher and psychologist.[26] It suggests that feedback from the body's response to emotional circumstances is a central determinant of felt emotion. While Lange emphasized the role of the cardiovascular system as a stimulus source, James included both autonomic and motor responses in his formulation. But they agreed on reverting intuition: we do not cry because we feel sorry; we feel sorry because we cry.

23 F. Esteves, U. Dimberg, C. Parra, and A. Öhman, "Nonconscious Associative Learning: Pavlovian Conditioning of Skin Conductance Responses to Masked Fear-Relevant Facial Stimuli," *Psychophysiology* 31 (1994): 375 – 385; A. Öhman and S. Mineka, "Fear, Phobias and Preparedness: Toward an Evolved Module of Fear and Fear Learning," *Psychological Review* 108 (2001): 483 – 522.

24 K. Carlsson, K. M. Petersson, D. Lundqvist, A. Karlsson, M. Ingvar, and A. Öhman, "Fear and the Amygdala: Manipulation of Awareness Generates Differential Cerebral Responses to Phobic and Fear-Relevant (But Non-Feared) Stimuli," *Emotion* 4 (2004): 340 – 353; J. Morris, A. Öhman, and R. J. Dolan, "Conscious and Unconscious Emotional Learning in the Human Amygdala," *Nature* 393 (1998): 467 – 470.

25 J. S. Morris, B. DeGelder, L. Weiskrantz, and R. J. Dolan, "Differential Extrageniculostriate and Amygdala Responses to Presentation of Emotional Faces in a Cortically Blind Field," *Brain* 124 (2001): 1241 – 1252; A. Pegna, A. Khateb, F. Lazeyras, and M. Seqhier, "Discriminating Emotional Faces Without Primary Visual Cortices Involves the Right Amygdala," *Nature Neuroscience* 8 (2005): 24 – 25.

26 W. James, "What Is An Emotion?" *Mind* 9 (1885): 188 – 205.

Of course, an idea as radically breaking with common sense as this one did not go uncontested. The famous physiologist Walter Cannon launched what was taken as a devastating critique of the James-Lange position.[27] His basic argument was that the physiological activation seen in intense emotion is too crude and too slow to account for the richness and nuance of emotional experience. Indeed, Cannon himself demonstrated that the patterns of physiological responses observed in anger and fear are indistinguishable and that it takes several seconds (sometimes even tens of seconds) for the autonomic response to reach its maximum after an emotional provocation.

However, given what we know today, this critique is not as damaging as commonly thought. Emotional information may reach the amygdala and start activating the bodily response within some ten milliseconds after reaching sensory receptors, and before reaching the adequate cortical areas for identification. The feeling may then take several hundreds of milliseconds to develop. Meanwhile, it is amenable to changes in the stimulus situation. For example, feedback from facial responses is highly patterned and available within a few hundred milliseconds. Furthermore, this feedback remains available even after surgery that blocks information from the body from reaching the brain, which may help explain why animals with such surgery (or humans with spinal cord damage that block feedback from the body) still appear to have emotion – another of Cannon's critiques of the James-Lange theory.

Feedback from the slow autonomic responses may not have to await the full-blown peripheral responses but may start coming in as soon as the relevant brain nuclei are activated. As Damasio pointed out, "as-if body loops" provide simulations of previously experienced 'real' emotional body loops in a compressed time.[28] Thus, the brain may have quite specific information from the body early enough to make it a factor in shaping emotional experience. Indeed, Damasio and his colleagues have shown that simply recalling certain emotional episodes sets off distinct patterns of activity in brain structures that regulate and represent bodily states – patterns that differ between emotions.[29]

Feelings are mental images arising from changes in "neural maps" that represent bodily activations.[30] Experimental data show that the anterior insula, located in the convoluted cortex between the temporal and frontal lobes, was activated when participants "listened for their heart beats," and that this activation correlated with the participants' emotional characteristics.[31] Furthermore, masking studies suggest that the insula is one of the brain areas exclusively correlated with conscious

27 W. Cannon, "The James-Lange Theory of Emotions: A Critical Examination and an Alternative Theory," *American Journal of Psychology* 39 (1927): 106 – 124.

28 Antonio Damasio, *The Feeling of What Happens: Body and Emotion in the Making of Consciousness* (New York: Harcourt Brace, 1999).

29 Antonio Damasio et al., "Subcortical and Cortical Brain Activity During the Feeling of Self-Generated Emotions," *Nature Neuroscience* 3 (2000): 1049 – 1056.

30 Damasio, *The Feeling of What Happens*.

31 H. D. Critchley et al., "Neural Systems Supporting Interoceptive Awareness: Evidence from Functional and Structural Magnetic Resonance Imaging," *Nature Neuroscience* 7 (2004): 189 – 195.

recognition of emotional stimuli.[32] Thus, there is good reason to associate the insula both with the registration of bodily responses in emotion and with emotional experience itself.[33]

So much for reflexive emotion – emotion is also a matter for reflection. It is obvious that people to a considerable extent construct their emotions. Depending on who we are, we may respond in vastly different ways to the same emotional stimulus. Many investigators have suggested that the perceived meaning of the situation is the central determinant of the emotional response. And emotional meaning, they claim, results from an appraisal process.

Appraisal theory is one of the dominant schools in the psychology of emotion.[34] An influential attempt to insulate the James-Lange idea about necessary bodily input in emotion from Cannon's critique proposed that cognition (i.e., appraisal processes) gives the specific emotional quality to an experience, while physiological activation determines its intensity.[35] For example, running up stairs produces an unquestionable activation of the cardiovascular system. The emotional ramification of this activation, however, is very different if we do it for exercise, to meet a lover waiting at the top of the stairs, or to escape from a maniac chasing us with an axe. These appraisal processes correspond to what the Stoics called the second movement of emotion.

Appraisal theory is too extensive a topic to go into detail here. The general idea is that a series of appraisal processes evaluates emotional stimuli and that the emotion is the outcome of the appraisal. The most basic evaluation is relevance. 'Relevant' in this context typically refers to whether the stimulus has any consequences for one's current goal scenario. If it has no goal relevance, there is no emotion. But if the stimulus has the potential to enhance or impede one's prospects of reaching a valued goal, it will evoke positive or negative emotions, respectively. Goal-congruent stimuli basically induce happiness: if one can attribute the enhanced goal prospects to one's own effort the likely emotion is pride; if they are attributable to another person the likely emotion is mutual affection or gratitude.

To further differentiate negative emotion, the involvement of one's self is crucial. If the event impeding goal prospects damages one's self esteem, the result is anger, particularly if another agent is involved. A threat to one's self results in fear; a loss to self, sadness. In this way, different emotions can be explained in terms of different appraisals. Indeed, the strong assumption is that a unique appraisal lies behind each emotional episode.

Another important dimension of appraisal concerns potential actions: "What can be done about the situation?" Here, controllability and its prerequisite, the stimuli's predictability, are critical: predictable and controllable

32 H. Critchley, C. Mathias, and R. Dolan, "Fear Conditioning in Humans: The Influence of Awareness and Autonomic Arousal on Functional Neuroanatomy," *Neuron* 33 (2002): 653–663; Carlsson et al., "Fear and the Amygdala."

33 A. (Bud) Craig, "Human Feelings: Why Are Some More Aware Than Others?" *Trends in Cognitive Sciences* 8 (2004): 239–241.

34 Klaus Scherer, Angela Schorr, and Tom Johnstone, eds., *Appraisal Processes in Emotion* (New York: Oxford University Press, 2001).

35 S. Schachter and J. Singer, "Cognitive, Social, and Physiological Determinants of Emotional State," *Psychological Review* 69 (1962): 379–399.

adverse stimuli generate less fear, anxiety, and pain than unpredictable and uncontrollable stimuli.

Although we discuss appraisal processes in terms of explicit mental activity, they need not be conscious. While originally conscious, appraisals, particularly immediate ones, may eventually become automatic.

Appraisal processes are also of different importance for different classes of emotion – primary versus complex or secondary emotions.[36] Basic emotions are hardwired and include a handful of universal emotions such as happiness, sadness, fear, and anger – and are triggered more or less automatically by biologically given sign stimuli. Indeed, as we have seen, we need not even consciously perceive these sign stimuli for them to elicit an emotion.

There are two classes of complex emotions. One class of complex emotions – which include attachment, caregiving, sexual desire, jealousy, and social rejection – is 'object oriented.' That is, one cannot consciously experience these emotions unless one is aware of the object. Another class of complex emotions builds on basic or even object-oriented ones, but is cognitively elaborated to reflect cultural and social influences and is predicated on a self-concept. For example, the culturally cultivated fear of nuclear holocaust or terrorism involves the basic emotion of fear, but woven into it is a network of objects – the military, 'the bomb,' 'evil others' – as well as socially determined beliefs about how the world is organized, characteristics of other nations and ethnic groups, and the perceived vulnerability of oneself and the group to which one belongs.

In terms of neural mechanisms, basic emotions primarily depend on the low road to the amygdala, whereas complex emotions require cortical processes. The link between the amygdala and the ventromedial prefrontal cortex is essential for transforming primary emotions into secondary ones.[37] In fact, the frontal cortex is central for the regulation of emotion. In order for study participants to succeed in inhibiting amygdala responses to gory pictures, the upper lateral areas of the frontal cortex, which are associated with executive cognitive control, were activated.[38] Similarly, these areas appeared to inhibit the enhanced amygdala response of 'nonprejudiced' white participants exposed to masked black faces (indicating an implicit racial bias) when the masking interval was extended to allow conscious recognition.[39]

So far the assumption has been that appraisal is a central determinant of emotion. However, the causal chain may be reversed. Phobias are intense, crippling fears of specific objects or situations. Most sufferers agree that their fear is out of proportion to the real danger involved. Nevertheless, when asked to rate the danger conveyed by a set of objects that includes the object of the phobia,

36 P. Johnson-Laird and K. Oatley, "Cognitive and Social Construction in Emotions," in M. Lewis and J. M. Haviland-Jones, eds., *Handbook of Emotions*, 2nd ed. (New York: Guilford Press, 2000), 458 – 475; Damasio, *Descartes' Error*.

37 Damasio, *Descartes' Error*.

38 K. Ochsner, S. Bunge, J. Gross, and J. Gabrieli, "Rethinking Feelings: An fMRI Study of the Cognitive Regulation of Emotion," *Journal of Cognitive Neuroscience* 14 (2002): 1215 – 1229.

39 W. Cunningham, M. Johnson, C. Raye, C. Gatenby, J. Gore, and M. Banaji, "Separable Neural Components in the Processing of Black and White Faces," *Psychological Science* 15 (2004): 806 – 813.

they rate the objects as more dangerous than do nonphobic individuals. This can be taken as evidence that the phobic fear reflects faulty appraisals. Alternatively, however, it may be an effect, rather than a determinant, of the phobic response, an attempt to make sense of, or justify, the irrational fear.[40]

Humans are prone to retrospective justifications. As dramatically stated by V. S. Ramachandran: "Your conscious life, in short, is nothing but an elaborate post-hoc rationalization of things you really do for other reasons."[41] Famous examples of this process were inspired by Leon Festinger's theory of cognitive dissonance, which stated that humans seek balance and consistency in their belief systems. As a consequence, we are motivated to restore balance when there are conflicts between beliefs or between belief and action. For example, when persuaded by shrewd social psychologists to publicly express a view that was inconsistent with their beliefs, research participants were more likely to actually change their beliefs if paid a small rather than a large sum of money. With a big reward, participants could explain away the dissonant action as 'I only did it for the money,' whereas, with a trivial reward, justifying the action was more likely to require a change in conviction.[42]

Similar processes may be at work in emotion. Even though specific stimuli automatically activate emotions, this automatic response often merely sets the constructive mind to work. We feel pressed to understand and to justify our emotions ('the man was so scary, so what could I do but try to escape?' or 'as adorable as she was, I just fell helplessly in love'), and we retrospectively manipulate emotion to justify our action ('I hit him because he made me so mad' or 'I certainly must be madly in love to act this stupidly'). Indeed, one attractive aspect of emotion may be that it provides a sanctuary from the social pressure on humans to make sense.

Largely based on his research on split-brain patients, who have had their two cerebral hemispheres surgically disconnected from each other as a treatment for epilepsy, Michael Gazzaniga argued that the pressure to justify one's actions reflects the operation of "an interpreter system" housed in the left frontal cerebral hemisphere.[43] According to this view, the brain automatically takes care of most of the exigencies raised by the interaction of person and environment. The fundamental interpretive component of the human mind comes in late to make sense of the unfolding scenario mindlessly managed by the brain, to fit it into one's worldview and self-image, and to keep constructing the narrative that we take to be our lives. Unlike all other creatures, humans can, by their access to language, keep a running commentary on their lives. As a consequence, we are prone to mixing up the commentary and the commented-on

40 A. Öhman and S. Wiens, "The Concept of an Evolved Fear Module and Cognitive Theories of Anxiety," in *Feelings and Emotions. The Amsterdam Symposium*, ed. A. Manstead, N. Frijda, and A. Fischer (Cambridge: Cambridge University Press, 2004).

41 V. S. Ramachandran, *A Brief Tour of Human Consciousness* (New York: Pi Press, 2004), 1.

42 L. Festinger and C. Carlsmith, "Cognitive Consequences of Forced Compliance," *Journal of Abnormal and Social Psychology* 58 (1959): 203–210.

43 Michael Gazzaniga, *The Mind's Past* (Berkeley: The University of California Press, 1998); Michael Gazzaniga, "Cerebral Specialization and Interhemispheric Communication: Does the Corpus Callosum Enable the Human Condition?" *Brain* 123 (2000): 1293–1326.

events in our memories, which may explain the unreliability of our memories.[44] But the commentary is not merely epiphenomenal activity. Rather, it gives consistency to the world and to our actions in it, and it helps us to cope with new situations by time-proven (and largely culturally and socially determined) formulas. In doing its work, the interpreter tries hard to be rational. Indeed, Gazzaniga claims that the interpreter is behind the human adoration of reason.

It appears that science is about to outline the neural geography of the eternal human struggle between emotion and reason inside our brains. Reason appears to reside in the left frontal cortex; its primary opponents, the basic emotions, are located in subcortical nuclei, including the amygdala; and the field of the struggle may be housed in the medial frontal cortex. However, as military analysts know, the geography in which battles take place is an important factor in their outcome, but it is far from a sufficient one. We must know the availability and quality of supporting forces and allies, the weaponry, the morale of the troops, and last but not least, the connectivity among the involved units in order to provide informed guesses about the battle's outcome. Similarly, knowing the location of certain functions in the brain is merely a first step in understanding as complex a phenomenon as emotion. But judging from the progress made during the last decade, there is reason to hope that the collective efforts of philosophers, anthropologists, psychologists, and neuroscientists may eventually pay off in a considerably improved scientific grasp of emotion's enigmas.

44 Elizabeth Loftus, "Planting Misinformation in the Human Mind: A 30-Year Investigation of the Malleability of Memory," *Learning & Memory* 12 (2005): 361–366.