Chapter 6
The Neuroscience of Emotion and Its Relation to Cognition

Thought by itself moves nothing (Socrates as quoted by Irwin 2007:161)

In recent years an appreciation for the emotional dimension of life has asserted itself in all of the major disciplines of the liberal arts. There is a good reason for this. While the dangers of passion are well known to all, this chapter will demonstrate neuroscience's contributions toward making the case for the necessity of emotion for effective cognition. As Socrates implies above, cognition alone and by itself lacks the capacity to move us to action or to grant a critical component to understandings and "realizations" that only experience can give. While an emotionally distanced attitude may be essential to science, as Scheffler (1982) observed, even the notion of the un-emotional scientist is incomplete. One can be passionately devoted to objectivity. If the "unexamined life is not worth living" certainly experience without emotion is pathologically empty.

One of the mnoost important contributions of neuroscience established in this chapter is that the brain can know the emotional quality of an object or an event before cognition and consciousness enter the scene. I will present the neurological pathways which contribute to this because the finding is so counterintuitive. Although this emotional appraisal may be outside of our awareness and lived experience, it has an enormous impact on the cognitive course of that experience.

We shall see that perspectives as different as philosophy, and artificial intelligence and neuroscience converge in recognizing the necessity of emotion for rational decision-making, bringing together two processes once viewed as diametrically opposed. This is only one of the fascinating examples of the capacity of neuroscience to penetrate the boundaries of academic divisions.

This chapter will also address one of the most contentious problems in neuroscience – that of clearly articulating the senses in which cognition and emotion emerge from separate pathways of the brain and the senses in which they are intertwined and inseparable. Evaluating this issue is still a challenge to the field of neuroscience and it is especially difficult for sociologists who are looking from the outside in. It is important nonetheless, for sociologists to become acquainted with the complexities of the issue and its various positions.

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There are many examples which suggest the ways in which the varied fields can be compatible. For example, many involved in genetics have come to appreciate the importance of the environment even as sociologists have recognized the importance of genes, although their effect on social activity is highly qualified. Neuroscientists have recognized the importance of self and the social nature of the brain, while sociologists have become interested in mirror neurons and their place in the development of language.

The Distinction between Unconscious Emotion and Conscious Feeling. In neuroscience this is evident in the reversal of the common sense notion of emotion. The traditional view put forward independently by William James and Carl Lange starts with something happening to trigger emotion. For example, losing someone we love or being insulted produces emotions like sorrow or simple anger, respectively, and these emotions lead us to weep or take steps to avenge the insult. The James–Lange "specificity theory" reversed this old four-stage order: (trigger, perception, emotion, and emotional expression). James and Lange suggested a process with only three stages (1) We get insulted; (2) We perceive it as such, and (3) This makes us angry and at the very same time, the body produces objectively measurable events in terms of physiological changes that we simultaneously experience consciously. These bodily changes (expressions) *are* the emotion. Here emotion does not cause the following behavior assumed in stage three of the old model because the behavior is the same thing as the emotion, i.e., the last stages of the commonsense model are collapsed into one (Fig. 6.1).

This perspective placed emotion solidly in human consciousness even if it was due to being conscious of one's bodily reaction. The key to emotions was the consciousness of our physiological reaction. James' classic example of fear has been often quoted:

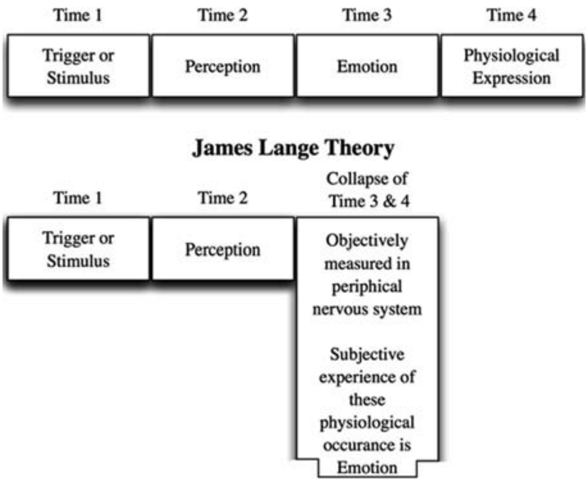

Fig. 6.1 Common sense notion of emotion

> I cannot help thinking that all who rightly apprehend this problem will agree with the proposition laid down. What kind of emotion of fear would be left, if the feelings of quickened heart- beats nor of shallow breathing, neither trembling lips nor of weakened limbs, neither of trembling goose flesh nor visceral stirring, were not present, it is quite impossible to think (James 1884: 193–194).

The ends up meaning that instead of crying because we are sad, we are sad because we cry, mirthful because we laugh, angry because we tense up and fearful, because we shake. This means that the physiological reaction to the stimulus is at the same time the emotion. The emotion here is conscious feeling of bodily reactions.

The James–Lange theory inspired a great deal of critical work over the early years of the twentieth century until it was finally accepted that at least parts of the theory seemed valid – namely that the bodily responses which are the emotion are shaped at least somewhat by the facial expressions they produce. There is significant evidence that we can sometimes transform our emotions if we are able to smile when we least feel like it. The result may not be large and completely reliable, but the effect of facial expression of emotion cannot be ignored, as many actors know. Cornelius (1996:101) says, "where the face goes the emotion follows." This conclusion came after the development of highly technical techniques that measure what goes on inside of the body during emotional experiences. Facial expressions of emotion seemed to accelerate that emotion, at least for some of them according to Cornelius (1996). As the lover in a parked car professes how he would travel the ends of earth to be close to the woman he embraces, he may or may not be successful in convincing the woman, but there is one person whom we *know* is turned on the more he professes his feelings and that one person is himself. Ekman and Davidson (1994) found significant increases in heart rate for the facial expressions of fear, anger, and happiness while anger increased most of all. Facial expressions of disgust produced a decrease in heart rate. No doubt this is why verbal assault so frequently precedes physical assault.

In a complete reversal of William James, current neuroscience differentiates emotion from feelings and often places emotion as essentially unconscious. Damasio (2003:19) argues that feelings are critical for the same reasons as sociologists do. It is only through what Wentworth and Ryan (1992) calls the "limbic glow" that emotion puts the *imperative* into duties, the *ought* into morality, and the *sting* into conscience. It is the "ego-alien" feeling of guilt, shame, and embarrassment that produce social order and give persons their own private reasons for avoiding these sanctions. People do not avoid these feelings so much for the sake of others but for their own sakes because they are profoundly uncomfortable. But the fact that feelings are conscious and vital does not mean they are "first" in a "causative" sense. According to Damasio, emotions, which are unconscious, are first and cause conscious feelings later.

Damasio (2003: 67–78) demonstrates this point by a patient who was a woman of 65 years with a long record of Parkinson's disease and was being treated with an electrical brain stimulation. She had no experience of depression. The doctors found that when they passed an electric current through the mesencephalon 2 mm below the contact that relieved her condition, the subject immediately stopped her conversation and was overcome with sadness. Suddenly she began to cry. She was in profound misery, and as her sobbing continued she began to say that she did not want to live and she was fed up with life. She continued saying that she felt useless and unworthy of attention. Realizing this, the doctor stopped the current and in 90 s she returned to normal. Her facial expression and words stopped as quickly as they began. According to Damasio (2003:69) "There were no conscious thoughts whatsoever to induce her behavior…. The display of sadness, in all of its spectacular complexity, came truly out of nowhere." The evidence, Damasio says, reveals first that the neural trigger of emotion was completely independent of conscious appraisal and second the dependence of conscious feeling and thought on emotion. What initiated the whole process had nothing to do with her consciousness at the very point of the electric stimulation (pure emotion). This was certainly embodied, but it was not caused by her thought, conscious, or unconscious. "Emotions come first and conscious feelings come after." (Damasio 2003: 29,101, 111). He also details other research that implies the same sequence.

Damasio also describes a phenomenon equivalent to the above except it was for laughter. This also involved a person undergoing brain stimulation. The purpose here was to locate precisely the area of the brain that needed to be removed to control seizures; but it was also necessary to know what nearby areas were essential to the patient so the surgeons could avoid injury. When they began to stimulate their target they noted that such stimulation at a number of related sites consistently and exclusively produced laughter. Like the lady's depression, this came totally out of the blue. The patient was not being told any thing funny nor was there anything that others saw as funny in the room. The laughter was followed by a sensation of merriment in spite of its involuntary character.

These two examples lead Damasio to collect other examples of emotion preceding thought. This was a significant challenge to cognitive psychology, philosophy, and sociology. And especially symbolic interaction all of which had insisted that linguistic appraisal directed emotion.

Why would Damasio insist on the causal position that the emotions came first? His first answer was that "We have emotions first and feelings after because evolution came up with emotions first and feelings latter" (Damasio 2003: 30). The earliest organisms maintained life with ways of solving the basic problems of life automatically. As these survival mechanisms get more complex, we finally have an animal with emotion. All organisms must successfully seek forms of energy, then a chemical balance must be maintained within the body, and finally the organism must develop immunity to disease and injury. This is what is meant by homeostasis. As we come to the animals with the most complex regulations from basic reflexes to drives and motivation, we finally come to animals with emotion. In an evolutionary perspective feelings are just "icing on the cake," but for conscious human beings this is a very important icing as Wentworth and Ryan (1992) and others knew. It follows than, that emotions and feeling are not synonyms. According to Damasio (2003: 86) "Feeling is the perception of a certain state of the body along with the perception of a certain mode of thinking and of thoughts with certain themes." As such they are at the top levels of the homeostatic regulation from simple to complex. We have seen that Damasio insisted that the critical characteristic of true emotion as part of producing homeostasis was its automatic and involuntary character. For Damasio the measurements indicating emotion were objective and arose from the body. They included (1) heart rate, (2) blood pressure, (3) skin conductance, and (4) endocrine responses, all of which are outside of our awareness.

Damasio's first real experiment demonstrating that emotions come first and thought afterward was inadvertently found in a study of the neural mappings of feeling. Somewhat like James, the hypothesis was that various signals from the brain mapped the physiological state of the body. Damasio's team had 40 normal subjects split evenly between genders. They told these normal subjects that they were studying patterns of the brain when four emotions were felt: fear, sadness, anger, and happiness. These emotions were measured by the amount of blood flow in multiple brain areas related to emotion. These included nuclei in the back of the brain stem referred to as the tegmentum, the cingulate cortex, and the insular. Normal feelings of emotion depend on the cooperation of all these areas especially the insular.

The areas were measured by blood flow which correlates with the amount of neuronal activity in these areas. Damasio's team asked each subject to pick one of the four emotions that where especially compelling. The researchers asked subjects to think in detail about the episode they chose prior to the experiment. Damasio and his colleagues determined the emotion each subject could relive the best, measuring heart rate and skin conductance. At the moment that they started feeling the emotion they raised their hands. In addition, data were collected on brain activity in all brain areas related to that particular emotion in order to measure changes with the different emotions chosen for each participants. Most important for my point is that changes in skin conductance (the measure for emotion) always came prior to the experienced feeling.

Damasio was not the only one to make this point. A philosopher named Ronald de Sousa (1987) summed up emotion as providing three critical functions. First, emotion sets the agenda of thought. Bureaucrats know that the agenda organizes what will be discussed and that this is a way to maintain power. The second function of emotion is that it sets what is important to us (salience) and thus tells us what we do not have to bother thinking about. Damasio's "prefrontal patients" could never make choices because without priorities everything was equal as an option. Third, emotion is what we see the world in terms of. When in love, a cold rainy day makes you want to cuddle up and when we are depressed music losses its luster and even a sunny day looks bleak and sad. The compelling nature of emotion lead to an understanding of why it is said that emotion drives and organizes the brain (Le Doux 1996). Also understanding emotions and the brain is not a matter of merely learning its separate parts. For many neuroscientists the brain is holistic. What is crucial is the particular interaction of the brain as a whole.

Finally many neuroscientists have agreed with Sperry who said that emotion seen as an emergent is not unrelated to its past. Evolutionarily, recent parts of the brain carry some elements of the old brain with them and new parts work back to affect the old. Lakoff and Johnson, as already noted, see the emergence of the symbolic as a totally new way of communication that is largely (but not wholly) dependent on metaphors that arise from bodily action.

Likewise it is worth repeating that "primitive" parts of the brain do not stay unchanged, but the new changes the old by means of its many neuronal connections.

Gazzaniga on Modulation and Emotion. There are two broad perspectives on the brain's construction – the modular theory and the more holistic network theory. The modular perspective is supported with some qualifications by Gazzaniga (2008). By the term modularity, he means that the brain is organized into relatively independent functioning units that work in parallel with the neocortex. Comprising 75% of the brain, the neocortex is the largest by far of the brain's components (Gazzaniga 1985:4). According to most neuroscientists, the mind does not solve problems in one single way Gazzaniga :147(2008). Certainly, any idea of a unified conscious is wrong even if questions still remain about modules. In fact, in the 1980s these modules were referred to as "an army of idiots" which have to be pulled together in some meaningful way by the left "interpreter" side of the brain. It seems that our brains have neuronal circuits which have developed over time to specialize in particular jobs. Damage to specific parts of the brain produces a lack of functioning in other parts. Currently evolutionary psychologists have proposed the idea of modularity as units of mental processing which evolved in response to selection pressures; however, Gazzaniga (2008) reminds us that "modules are defined by what they do with information, not the information they receive." According to Carter (1999:16), the modules that nestle beneath the corpus callosum are generally known as the limbic system, which is associated with emotion. It is clear, however, that modules are not like isolated units that are stacked up neatly in the brain (Gazzaniga 2008: 127). On the contrary, the electric currents for these modules are widely scattered throughout the brain.[1]

Five modules have been postulated to elicit moral emotions. Gazzaniga offers some reasons why we would not want a world which was completely rational and devoid of emotion. He gives the example of why we leave tips in restaurants to which we will never return. Haidt (2005) makes the point that there are more to emotions than altruism and niceties. Emotions which lead to righteous vengeance, ostracism, and shame are no less a part of the human moral nature and should also be seen as be seen as moral emotions. Emotions can show moral authenticity. Humans are the only animals that cry out of distress and thus we have a tendency to be trusted as such times.

As we know, emotions can overcome pure rationality. For example, despite our current present divorce rates, people still seem eager to get married and lavish a great deal of resources on wedding ceremonies and receptions. A purely rational person with no emotions of social control or fidelity would be very wary of going into partnerships since a purely rational partner like himself would be likely to be

[1] The modular theory of the brain was a creation of evolutionary psychologists and has come under a great deal of criticism. They present modules as being laid down far in the evolutionary past. It is hard to imagine that the human brain has not changed fundamentally in the last 100,000 years or more (See Small 2008).

unfaithful. Emotions generated by this problem according to Gazzaniga (2008:132), as love and trust can lead to marriage and trust leads to partnerships.

Gazzaniga describes five moral modules that are most commonly discussed. I will list only one example since he offers so little evidence for his modular thesis. This is *reciprocity* and needs little elaboration for sociologists. Moral emotions generated by reciprocity are gratitude and a sense of being cheated when one does not receive reciprocation. Christmas cards were sent to a list of people whom the recipients did not know, but most of those receiving cards sent cards back without even asking who the senders were. Although I have not found specific information on the anatomical areas of the brain that can be considered "seats" of these modules, there are hypotheses, however, about areas supporting depression which could be seen as modules. It should be re-emphasized that this is in contrast to a holistic position that places the connections across multiple brain areas.

Mayberg's Work on Brain Areas Especially Related to Depression. According to Dodds (2006) in the mid-1990s, Helen Mayberg and Wayne Drevets, now at NIMH, independently isolated a particular brain area just over the roof of the mouth deep in the older part of the cortex identified as area 25.[2] They were interested in finding ways to curb depression which is characterized by brain under activity, particularly in frontal areas involved in thinking. Early in her career, Mayberg had inserted pace-like electrodes into this spot deep in the cortex. She found that area 25 was a conduit of neural traffic between the "thinking" frontal cortex and the deeper, central brain region associated with emotion. This area is like a gate left open which allowed negative feelings to impact on the frontal cortex. Usually depression is associated with a lack of activity in these parts of the brain. But in her patients, area 25 was particularly over-active. Even though Mayberg did not know how area 25 modulated traffic between these areas, it was obvious that the area was very fundamental to depression.

At the turn of the century, Mayberg's research revealed more. Healthy subjects were asked to think sad thoughts and then were scanned when the tears were flowing. The scanning showed depressed activity in the frontal cortex and a hyperactive area 25. She also found that patients who recovered had increased activity in frontal activity and a calming in area 25. As usual there was a problem of establishing cause based on a correlation. Depression either decreased frontal activity in area 25 or rose from hyperactivity in that area" (Dodds 2006; 173).

In (2004) Mayberg scanned two groups, one going through drug treatment with Paxil and another utilizing cognitive behavioral therapy. The patients receiving Paxil showed the usual pattern when recovering, but the frontal areas of the cognitive behavioral group displayed a calming of area 25 when this group became better. Oddly, the frontal areas exhibited diminished activity instead of the low to high pattern of drug treatment recovering groups. At first this did not make sense, but the

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[2]Brodmann's area 25 is in the brain's cerebral cortex and the region called the subgenual cingulate. This is a map of the brain's cytoarchitectural structure used to determine different cellular tissues in the brain and their functions by staining the tissue to distinguish nerve cells.

answer was found in a selective bias in the patients. Successful cognitive behavioral therapy patients showed activity in the frontal area because they were more fit for such treatment, namely because they were busier thinkers by nature which attracted them to this particular therapy. They were already trying to think their way out of their moods. The frontal areas could relax when they started to come out of the depression. Regardless of these differences, area 25 was overly busy in all types of depression and was calmed as treatment became effective. Starting in 2003 Mayberg and her team inserted electrodes in area 25 in severely depressed patients. A pair of nickel-sized holes were drilled in the top of patient's skulls and electric leads connected to a small pacemaker were sewn under the collarbone sending a 4-volt current to area 25.

This treatment met with remarkable success. Some patients felt immediate relief and two-thirds recovered within months. Mayberg still does not know why calming area 25 has such an effect but it is now well established that when this area is overactive it causes depression and when it is calmed down it brings relief.

Mayberg's work would seem to be at odds with that presented by Gazzaniga because it strongly confirms a network model of the brain. Reason, passion, thought, and emotion are linked in a loop as Dobbs puts it, they are not stacked in a hierarchy with cognition reigning supreme.

Parts of the Brain Related to Emotion

Neocortex. We have seen that the neocortex is the largest component of the brain by far. Its expansion to the human cortex in the frontal lobes is critical to thinking, planning, and language. Motor areas, the sensory cortex, and association cortex lay behind the prefrontal lobes. These lower level structures readily overpower and regulate higher neural structures. Carter (1999) informs us that the wiring from this lower part of the brain is robust and thick going up the cognitive systems, but the reverse is not true. Cognition going down the emotional systems has to fight a tough battle to make an impact.

Cingulate Cortex. Running from front to back of the corpus callosum is the cingulate cortex. Especially related to emotion is its frontal region which plays a strong part in depression and sadness. Cognitive processes are involved in its posterior section. The cingulate cortex supplies an integral part of our ability to map somatosensory systems that create bodily feelings. The "limbic glow" that compels us to follow rules and act in a way which avoids sanctions is also in large part due to the cingulate cortex. The capacity to have feeling depends not only on the organism having a body, but it must also represent that body inside of itself. As we have seen, there is much more to emotion than feeling, but feeling is vital nonetheless. Surgical destruction of the cingulated cortex has relieved patients of intractable pain, but the right side of the brain produces negative emotion and the left side produces positive emotion. If a person were to have a stroke it would be better to have it on the right side because the negative emotion would be dampened. According to Turner

(1999) the cingulate cortex integrates emotion with the forebrain and it is well connected with other structures. The front of the cortex is also connected deeply with the amygdala.

The Insular. The insular has been partially described in Chapter 3 as a latecomer on the neurological scene because it was deep inside the temporal lobe meaning that the lobe has to be pulled back for the insular to be seen. Damasio (2003) sees it as the most important site of feelings and calls it pivotal to emotion. Signals of emotional feelings are sent from the brain stem to a dedicated part of the thalamus to neural parts in the front and back of the insular. Next, the insular sends these messages on to ventromedial prefrontal lobes and the anterior cingulate cortex. The insular plays a large part in organs having to do with maintaining the bodily homeostasis and from which unconscious emotion is derived according to Damasio. The cingulate cortex and the insular are important sites of feelings stemming from ingesting ecstasy, heroin, cocaine, and marijuana. Damasio (2003) considered the body sensing regions such as the insular to be the sites of the neural patterns which are the proximate cause of feeling states.

The insular is connected with an astonishing number of brain areas and it has an equally bewildering number of functions. Connections include frontal lobes, Broca's area, cingulate areas, temporal lobes including Wernicke's area, the amygdala, hippocampus, and the periaqueductal grey matter, and other areas of the brain stem.

Hippocampus and the Amygdala. The hippocampus and amygdala lie at the center of the brain deep inside the cerebral cortex. The amygdala consists of two eye-like structures that protrude out of the front of the hippocampus. The hippocampus is a long structure whose tail wraps around the front of the thalamus. The amygdala wraps around this front end. We have seen that it is an instantaneous warning system because sensation plays an important part in fear. Of all the many parts of the brain, the amygdala is most involved in emotion. It plays a pronounced role in evaluating negative emotions and emotion in general. According to Birggit Röttger-Rössler and Markowitsch (2009), amygdala damage in patients produces deficits in memories and impairments in attending to relevant aspects of their social environment. Patients with Urbach–Weithe disease are an example. Urbach–Weithe disease is inherited and in two-thirds of the patients; it leads to bilateral calcification of the entire body. Changes in social behavior included problems with integrating memory and emotion as well as inappropriate behavior. This is a common finding.

Studies with large samples of Urbach–Weithe patients found serious problems with their ability to identify expressions in the faces of others. Other patient studies also demonstrate the central role of the amygdala in evaluating emotions in general and negative emotions in particular.

While the task of the amygdala is to search the social and physical environment for danger and to react with lightening speed, the slower and more considered input from the cortex gives a more considered assessment. In both cases inputs to the senses proceed first to the thalamus where they are sorted out. In the case of something provoking alarm, the information is split along the two paths and both are sent to the amygdala.

Inputs from the quick path of the nearby thalamus are a one-way street which bypasses cognitive control. The slow path sends information to the visual cortex in the back of the brain and, as we have seen in Chapter 4, breaks it down into “feature extractions” like shape and depth and sends this forward to areas in the prefrontal lobes that identify exactly what the object is. Finally, the prefrontal lobes send the refined information to the amygdala which generates the emotion compelling the body into action. In the fast route, only the thalamus and the hypothalamus are involved. They are very close to the amygdala and this provides the quick but unreliable path from eyes to body in milliseconds (see Carter 1999: 94–95). The mechanism both creates and then receives its own cortical input – a most curious interaction (LeDoux 2000). This one example gives us an important insight into the enormous complicity of the brain (Fig. 6.2).

Diencephalon. Between the cerebral hemispheres and the midbrain lies the diencephalon. The midbrain lies on top of the brain stem and connects with the spinal cord. The diencephalon and the pituitary gland mediate sensory inputs which carry emotional charges. They also produce hormones and peptides responsible for emotional behavior. The diencephalon is composed of the thalamus and the hypothalamus, which lies in front of and below the thalamus. The thalamus processes and distributes sensory data from the periphery to the cerebral cortex. This cerebral cortex covers the top and sides of the brain with dense cell matter and interprets meaning before emotional responses. The thalamus determines whether its information gets to awareness in the neocortex. The pea-sized hypothalamus controls the autonomic nervous system and hormonal secretions by the pituitary gland. It has input and output connections to all the regions of the central nervous system which are critical to emotional feeling. Bodies within the diencephalon integrate

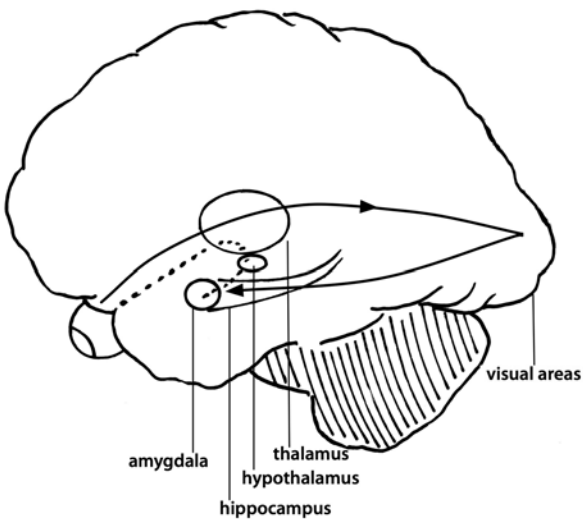

Fig. 6.2 Fast and slow routes of the amygdala

emotions and memory. It has been known for a long time that aspects of our lives are best remembered when they are emotional. Units within the diencephalon select information for long-term storage. Chronic alcohol abuse leads to the destruction of the thalamus and the hypothalamus. These patents become emotionally flat and detached. They are also unable to generate emotional involvement in ongoing events (Röttger-Rössler and Markowitsch 2009: 117). Traumatized insulars are associated with apathy and an inability to tell fresh from rotten food. The insular reads the physiological state of the whole body and then creates the subjective feelings which can bring about activities related to homeostasis such as eating to keep the body in a standard state of balance.

Brain Stem. The foundation of basic life maintenance functions such as metabolism is seated in the brain stem. Its predecessor was formed 500 million years ago and is similar to the brain of current reptiles. Because of this it is called the reptilian brain, as it is the conduit between the front of the brain and the body and vice versa. The forebrain's ability to create the feeling of pleasure or pain depends on making its way through the brain stem. Damage to the brain stem most often results in loss of consciousness and thus feeling. Damasio (1999) states that areas of the brain stem work with the forebrain structures of the cingulate cortex and the prefrontal cortex to generate consciousness, including unconscious emotional states. Other structures playing a lesser role in awareness are the cingulate cortex, forebrain structures, and prefrontal cortex.

Midbrain. On top of the brain stem is the midbrain which harbors a group of nuclei referred to periaqueductal grey matter. This area is critical to the high order control of homeostasis and a significant part of the control of emotion. The periaqueductal grey releases opiod neurotransmitter receptors which are important to many emotional states. Panksepp (2000) suggested that this is the area that first allowed animals to cry out in pleasure and distress.

Orbitofrontal Cortex and Phineas Gage. A great deal of clinical data suggest that the ventromedial prefrontal lobes have more influence on social and emotional processing than any other brain structure. The best known case demonstrating the function of the ventromedial prefrontal lobe was that of Phineas Gage who lived in the mid-1800s. His case is so important to neuroscience that I will describe it in some detail.

Mr. Gage was in charge of a large number of men laying down new track for railroad expansion. While he was well liked and athletic, Mr. Gage was more than that, he was the most capable, reliable person in the whole group. They had to work with outcrops of very hard rock. Blasting stone with explosives was a regular part of the job; to blast the rock, a hole must be drilled and filled half way with powder, then filled with sand. It required that the sand be pounded carefully with an iron rod. Distracted by one of his men, Gage did not realize that the sand had not been poured in the hole and he tapped the powder with an iron bar. A brutal explosion shot the rod into Gage's right cheek and then went through the top of his head. The rod flew out and landed more than a hundred feet away. He lay on the ground awake but he did not speak. As soon as he spoke his men put him into a cart in which he sat erect for three quarters of a mile to a shelter.

When the doctor finally came, Gage spoke with him in his usual manner and his wound has dressed successfully. Gage's physical recovery was complete. But after he healed, his behavior changed. According to his friends, "Gage was no longer Gage." His new behavior prevented him from finding work because of his lack of self-control and temper. The story of Gage gets worse, not better. He died an early death at 38 unable to keep a job or interact socially. Damasio (1977:10) says that this "hinted" at an amazing fact: somehow there was a part the human brain which had a large part to do with an intact orbital frontal lobe that was dedicated more to reasoning then to anything else. Gage's detriment included an impairment of the personal and social dimensions of reasoning. This was true even though his basic intellect and language remained unaffected and he constantly defined and interpreted his environment just like every body else. Much later his skull was examined and it was discovered that the initial site of injury was probably the orbital frontal region (Fig. 6.3).

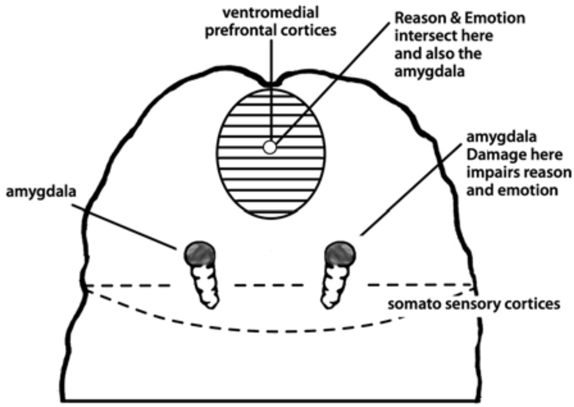

Fig. 6.3 Areas whose damage impairs emotions reasoning affecting decision-making

Damasio's Somatic-Marker Hypothesis

In 1994 Antonio Damasio wrote *Descartes' Error* and continued the story of Phineas Gage by using that case to develop hypotheses about patients who were similarly traumatized in the ventromedial part of their prefrontal lobe. Metaphorically, reason and emotion intersect in these cortices (Damasio 1994:70).

To set the stage for Damasio's hypothesis and to demonstrate how emotion relates to decision-making, it will be instructive to relate story about how the AI (artificial intelligence) workers found the need of emotion for the decision-making which neither Gage or Damasio's patients could do. The story refines the discussion about emotion setting saliency.

We are asked to imagine a robot being told that a bomb was to be set off inside its hanger. To no one's surprise the robot decides to leave, but as it turned out, the bomb was in its own wagon and went off. The robot knew this, but being a machine, it had not drawn the inference because it had not been wired to do so and he was blown to pieces. Therefore, the robot's builders picked up his remains and made robot number two. This time they made sure that it was set to draw the consequences of what it knew. We humans do not need to be told all the steps to make a decision but the robot is basically a computer. That meant that the AI workers needed to know all of the steps involved. This illustrates the interesting ethnomethodological insight *that we need to know much more than we think we know in order to know anything at all.* It was no wonder then that the AI workers were faced with a challenging task both for their robots and themselves. When the experiment was repeated and the robot had to decide whether to leave or not, it remained stalled in its tracks still trying to think of whether or not leaving the hanger would change the price of tea in China. This was because the robot, being absolutely objective, had to give equal weight to literally all the consequences it could think of. Of course, the bomb went off again.

Undaunted, the AI workers went back to work on robot number three telling it to only think of *relevant* consequences, but once again the robot remained unable to decide to leave the hanger. This time, its creators yelled, "Do something!" but it answered, "I am! It takes time to ignore thousands of implications that I have determined to be irrelevant." de Sousa's point is "*that we need to know whether a consequence will turn out to be relevant before drawing it*" (de Sousa 1987: 194). The solution to the problem is relevancy and that is set by emotion. Another conclusion is that there is no such thing as pure reason separated from emotion. As de Sousa puts it: no logic can set saliency.

Characteristics of Damasio's "Prefrontal" Patients. Going back to Damasio's patients, most, like Gage, had been successful in their businesses and professions as well as social lives before their injuries. After their injuries they were especially poor in judging people, making decisions, and learning from previous emotional experiences. Also like Gage, after their trauma their lives unraveled socially at home as well as in business.

During interviews the patients told of their loss in a very matter of fact manner while it was all that the interviewers could do to hold back their tears. The patients could not even sympathize with themselves. When asked to look at photos of car wreck victims that would have made anyone cringe, they sat emotionless; they recognized cognitively the devastation and anguish the pictures conveyed, but their bodies showed none of the skin conductance responses that indicate emotional feelings. They could talk about feelings in this context but could not feel them. They were capable of doing well on a variety of tests which would make them appear perfectly normal – they could "talk the talk" as Damasio says, "but not walk the walk" in non-verbal real life.

"Elliot," for example, had been a successful professional and a community leader before his trauma. He was given a number of tests dealing with social convention and moral value. The tasks involved in the test included awareness of the consequences of action, ability to conceptualize means of achieving a social goal, ability to predict the social consequence of events, and a test of moral judgment. Elliot's scores were excellent. The trouble was that his words contrasted with his deeds. He had cognitive access to social knowledge but he could not apply it. Never in the tests did Elliot have to make real-life decisions. In another interview, after producing a list of options for action that were impressive in quantity and quality, he said, "After all this I still would not know what to do" (see Damasio 1994) It appears that Elliot had the same problem as the robot and in his own way he had blown up because of it. *Without emotion eliminating certain possibilities as unthinkable or emotionally preferred, there was no basis on which to decide.*

The Somatic-Marker Hypothesis

Whether Damasio was aware of the robot story is a matter of intellectual conjecture, but it is clear that both narratives demonstrate the place of emotion in rational thought. Damasio starts by pointing out that experiencing the fact that an option has had a bad consequence in the past is dependent on one having a particular gut feeling when the option comes up again. In emotional terms, I would think the thought of choosing this option would usually be met with "apprehension." In Damasio's words, it "marks an image." This embodied "marker" forces attention to the negative outcome and functions as an alarm bell (Damasio 1994:174). The number of options under scrutiny depends significantly on one's intelligence and the "theater of the mind," but the actual choice can depend on messages from the "theater of the body" which produce apprehension. The partnership between cognitive processes and emotional ones is clearly established.

In order to test his hypotheses, Damasio and his team created a gambling card game which is made as life-like as possible. It poses the risks of real life as well as its uncertainty. It offers choices but no gives no indications of what to choose. The goal is to lose as little as possible and to gain as much as possible. Four decks of cards labeled A, B, C, and D are placed in front of the player. The player is given $2,000.00 dollars of play money to start the game. He/she is instructed that all cards will earn at least some money. However, some cards will also demand that players *pay* some money. No written records were allowed. Deck A was usually worth $100 dollars as was Deck B. However, both sometimes imposed a $1,250 fine. Decks C and D were only worth $50 dollars but sometimes they too demanded a payment. These were less than $100 dollars on the average (Fig. 6.4).

Since none of the players knew this, healthy players typically sample from all decks looking for clues. Usually they gain a preference for decks A and B but within the first 30 moves they come to prefer decks C and D and retain this preference to the end. Little by little they develop an apprehension about decks A and B because although some times they gain with them, there are also times they really get "burned."

As hypothesized, things were different for the ventromedial prefrontal patients. In fact, their choice-making behaviors were just like those they had exhibited in real life and diametrically opposed to the comparison group. They were attracted to the A

Fig. 6.4 Gambling decks

Decks	Reward	Possible Cost
A	100.00	Sometimes comes with a fine of 1,500
B	100.00	Sometimes comes with a fine of 1,500
C	50.00	Sometimes you won 100 or less $\overline{X}$ = Less than 100, which is not bad
D	50.00	Sometimes you won 100 or less $\overline{X}$ = Less than 100, which is not bad

and B decks and declined the safer C and D decks. Because of their preferences, the penalties they sustained were disastrous and they were bankrupt half-way through the game.

As usual Elliot was particularly interesting. When the game was repeated after several months he differentiated the safe decks from the high risk one's but he did not behave any differently in his choices from the first game to the choices he persisted in making in real life (shades of Phineas Gage). "As with his other behaviors" Damasio (1994: 115) says, "we can evoke neither lack of knowledge nor lack of understanding of the situation." This was true of all Damasio's prefrontal patients. Interestingly, those with large lesions in other close-by regions could play the game as normals could.

There are always competing hypotheses and one of several possibilities that Damasio explored was that his "prefrontals" were only motivated by reward and not sensitive to punishment. To test this possibility, the schedules of reward and punishment in turning the cards were reversed with the punishment coming first. The patients would actually avoid the bad decks for a while after getting "punished" but this never lasted very long and they went back to drawing the risky cards. Deprived of a reliable and steady concern for future consequences, the prefrontal patients had no way to control their impulses and bank on the future. This deprives the patients of one of the most distinctive of human traits which is the ability to be guided by images of future prospects rather than insisting on immediate rewards. Damasio calls this a myopia for the future.

In a replication of Damasio's somatic-marker hypothesis, Carter and Pasqualini (2004) provided important support for the external validity of Damasio's thesis by using normal female patients. Somatic markers are not just the consequence of the ventromedial prefrontal cortex. The information which they coordinate is strongly connected with other systems of the brain. These include the somatosensory and insular cortices, the brainstem nuclei, and the amygdala. These produce a replication of the emotional consequences of choosing previous cards. Thus, skin conductance reactions became a major indication of the existence of an embodied marker in Carter and Pasqualini's replication. It had been shown before that skin conductance had not been strong enough to steer brain-damaged patients from making risky decisions. Controls were considered homogeneous and even had almost identical skin conductance responses within their group.

Results showed that the stronger the autonomic response before risky choices, the greater the success in the game.

However, limitations of the somatic-marker hypothesis remain. By necessity the experimental group was limited to a small number of patients, even if the data on the women received strong support. We need to remember that in this case and others, the neural substrates of the semantic marker hypothesis are not fully established. We also do not know which specific emotions are related to somatic markers, such as feelings of foreboding and apprehension.[3] Damasio's argument is not the only one that places emotion as necessary for cognitive decision-making. We have to remember the convergent findings to that effect by the artificial intelligence workers.

The Limbic System Debate

Early in the last century, sensory perception and control of bodily movement were understood as being located in specific areas of the brain.[4] This encouraged others to think that emotions also had a dedicated center in the sensory cortex. In Jamesian fashion this drew researchers once again into conscious feelings. Emotions were considered the cortex's perception of the bodily feelings preparing for action in their appropriate situations. We ran not because of fear, but we fear because we ran. But Cannon (1928) demonstrated that the removal of the neocortex did not impact on emotional responses. If the neocortex was irrelevant to emotion, the search for its "home" was pushed down into the deeper parts of the brain parts "limbic system."

MacLean's Triune Brain. This comprised a discrete network of primitive structures between the supposedly more recent structures and the brain stem (Franks 2006:49). MacLean's argument was thoroughly evolutionary. The neocortex at that time was thought to have the learning capacities of mammals as apposed to reptiles. MacLean (1949) call the Limbic system the "reptilian brain." The limbic system was composed of the hippocampus including the thalamus and the amygdala. His association with the limbic system and the reptilian brain was an offshoot of his belief (in opposition to current scholarly thinking) that emotion was a primitive reaction involving our blind visceral reaction to environmental stimuli. According to MacLean, this notion of mentality "eludes the grasp of the intellect because it its ancient structure makes it impossible to communicate in verbal terms".

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[3]For a further highly technical critique of the somatic-marker hypothesis see Rolls (1999). He sees the somatic-marker hypothesis as a weakened James–Lange theory.

[4]This section relies heavily on David Franks (2008).

Difficulties in MacLean's Theory. Phylogenetically then, humans have three brains from major evolutionary periods – the reptilian brain, the paleomammalian brain, and finally the more advanced neomammalian brain shared with later mammals and other primates. We know now that these levels of evolutionary brain development have influenced and changed each other. They certainly do not have their own kinds of intelligence, memory, and other features that would be characteristic of any age of evolution. MacLean's theory also helped retain the devaluation of emotion by associating it with the primordial.

With the development of neuroscience, the cortical areas became impossible to order phylogenetically; this advancement rendered the evolutionary perspective of MacLean no longer viable. Primitive creatures had rudimentary cortices similar to the advanced mammalian neocortex. This meant that there was no distinctive reptilian which had remained unchanged throughout our evolution. The areas were just located in different places and had been hidden. MacLean had defined the limbic system as being comprised of any structure connected to the hypothalamus, but as research proceeded, it became clear that all of the areas were so integrated that they had essentially become new structures. This is an excellent example of Sperry's statement about the new carrying with it the old and vice versa. Taken as a whole, the old structures were not what they used to be. Also some structures outside of the limbic system were more closely related to emotion than were some areas of the limbic system. The final blow to the idea of the limbic system as the seat of emotion came when researchers found that all parts of the limbic system were not connected to the thalamus and the hypothalamus and that the thalamus actually had more connection to the cognitive process including declarative memory.

Why the Limbic System Did not Die. Even with all these limitations, the concept of the limbic system refused to leave the neuroscience scene. One reason that the amygdala proved so valuable to research was because it sits conveniently in front of the limbic system and is relatively available for research. It also has a very low threshold to electric stimulation as a function of its fast path. The amygdala is called the gateway to the limbic system for these reasons. Damage to the cognitive areas involved in the amygdala's slow path affected those pathways that work down to decrease and control its emotional strength. The consequences of such damage include decreasing the ability to understand the emotional implications involved in social interaction and to respond appropriately to those implications (Fig. 6.5).

The amygdala is more closely involved in emotion than any other area between the hypothalamus and the neocortex. However, it is not involved with all affect and commonly depends on areas outside of the limbic system in forming emotions. Some researchers think that it might be easier to study emotions separate from thought and cognition because the fast system of the amygdala was so closely connected to the thalamus that it could send noncognitive messages directly from the outside environment without involving time-consuming pathways for input from the distant neocortex (Franks 2008: 50).

While originally the limbic system was reified to explain all emotion and it was located in one specific part of the brain, emotions came to be seen as involved in many places tightly interconnected with cognition, memory, and motivation. In

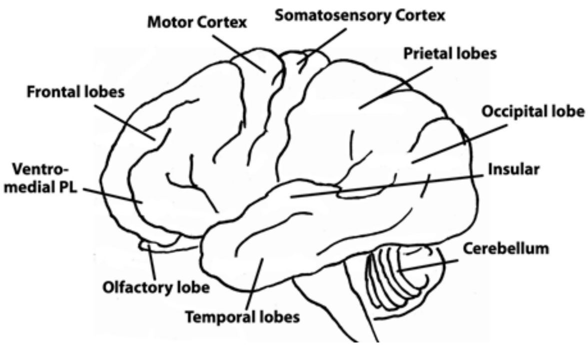

Fig. 6.5 Emotion related structures of the brain

other words, there is much more to emotion than the limbic system. According to Berridge (2003), "the neural substrates of feeling and emotion are distributed throughout the brain from front to back and top to bottom." The criticisms of the limbic system by LeDoux and others are now accepted in neuroscience, and it was for this reason that LeDoux chose to title his book, *The Emotional Brain* (1996). Others have suggested that so long as we are aware of the deficiencies involved in the concept of the limbic system, we may still benefit from its use. It communicates a great deal of information very quickly.

Challenges to Cognitive Appraisals Seen as an Inherent Part of Emotions

We have seen that Damasio and other leading neuroscientists have insisted on the causal priority of emotion over thought. To Clore and Ortony (2000) the "cognitive core of emotion" acts as the representation of emotional meaning. Their definition of cognition is so encompassing that it includes such varied processes as perception, attention, and even action. Of course, they also include appraisal. These authors would argue that a belief that someone may be stealing from you and the anger which results from that belief, do not occur in that order. Rather they are parallel and separate ways of experiencing the personal significance of what is happening in the world outside of your will. Emotion represents the mute character of expressions coming from the "theater of the body"; others who are more interested in cognition see the intertwining of cognition and emotion (such as in "appraisals") as coming from the "theater of the mind." Each process is independent of the other. Fear produced by the amygdala is definitely related to consciousness, but because of its speed (even in the long, cognitive path of the amygdala) we have already acted before we know just what it is that we are afraid about.

In fact, Ohman et al. (1999) produced a study making just this point. He recruited two groups: those who professed to be very fearful of snakes and a comparison group of those fearful of spiders but not snakes. The control group said they were not afraid of either one. Subjects were exposed to pictures of snakes, spiders, flowers, and mushrooms at a speed much faster than that which allows conscious perception. Those exposed to the snake slides, who were fearful of snakes had higher skin conductance with pictures of snakes but not with pictures of spiders. Similar results were found for those fearful of spiders and not fearful of snakes. In sum, subjects had shown increased sympathetic responses to pictures which triggered fears without being conscious of them.

A significant challenge to the position that emotions are an inherent part of emotions was provided by the two examples of electric stimulation of the mesencephalon described earlier.

Some have tried to keep the idea of appraisals as essential to emotion by labeling the behavior in these cases by the broader term "affect" rather than emotion. But affect is usually used to mean arousal – a much broader term, which does not distinguish between laughter and depression. The fact remains, however, that the subjective experience of these epileptic patients was that of emotion. This reduces the argument for the absolute necessity of appraisal for emotion to a mere word game.

The Fallacy of Either or Thinking. A common feature in the public's thinking about emotion and cognition involves either/or thinking; in this case, as in dualism. Emotions and cognition have been defined in such a way that there is an antithetical friction between the two, which are seen as antithetic to each other. Traditionally, emotions and reason are seen as inherently in opposition to each other while this chapter has argued from several directions that some emotions are necessary for effective thought. A more productive approach might be to address how emotions can most often be inextricably linked with cognition and at the same time be in tension as when we struggle with our diet or in the many times when reason dictates one thing and our passions dictate another.

Leslie Brothers Social Constructionist View of Emotion. Following social constructionists Perinbanayagam, Coulter, Haare', and Dennett, Leslie Brothers has challenged the neuroscientific world by proposing that emotions are not a brain function, but rather a function of social communication. She replaces the term emotion with the concept of "action tendencies" by which the brain readies the organism to act. When these potentials are extreme, they are socially labeled emotion. This means that the brain's action potential is real enough, but the interpretation of the behavior is a social construction. This construction is made to appear real by the circular process of the "documentary method" wherein the factualness of a concept is made to appear true by interpreting all that happens as consistent with the expectation.

Brothers (1997 and 2001) contends that there is no clear difference between the notion of emotion and general subjective experience. We only have the tendency to use the label emotion when the body is more mobilized. The limbic system is not totally eliminated because it generates strong action tendencies linked to the body such as tears, the sinking sensation of fear, and the bodily expressions called joy.

Next, Brothers reminds us that labels are essentially interpersonal, communicative acts. Facial expressions are communicative, sending signals to others which we label anger, fear, or compassion, etc. She notes that even Perinbanayagam (1989) and Coulter (1989) retain hints of the assumption of emotion as real. Perinbanayagam holds that bodily sensations cooperate with emotional symbolic constructions and Coulter proposes that physiological substrates enable, but do not cause emotion.

She ends her argument by suggesting that if we use the term emotion at all, we should think of it as a system of social regulation, frequently involving bodily changes that act as symbols. Fear and anger, for example, impact the behavior of others. She says, "that in the tradition of symbolic interaction... we can say that the meanings of a threatening facial display comes into being through what they call forth in the other" (Brothers 1997: 123). It comes as no surprise that her impact on neuroscience has been minimal in this particular case, but herein, she presents sociological argument that she uses later (2001) for a thorough going critique of present neuroscience.

The Seven Sins of Emotion Schacter (2001) warn that there are a number of false beliefs about interactions between the behavioral expression of emotion and their underlying neurobiological substrates. Schacter (2001) has called these false beliefs the "seven deadly sins" in the study of emotion. They are as follows:

Separate independent circuits subserve:

(1) Affect and cognition. There are clearly different positions on this matter, which make it important to understand how they are meant.

We have seen from the story of Phineas Gage and his similarities with the more detailed studies if those traumatize in the ventromedial prefrontal lobes that emotion is necessary to rational choice. This is because emotions are integrated in this area so they are not separate but integrated. Emotion, not logic sets salience and without a number of predetermined preferences there is no way to chose. Few people in the United States and other places seriously have to decide whether to have their pet cat for breakfast. It is among the many "unthinkables" needed for choice to proceed. To be "objective" in the dictionary sense and to really consider all choices equally makes decision-making impossible.

However Damasio (1994), LeDoux (1996) and Zajonc (2001) do indeed see cognitive and emotional processes as emerging from separate, but interacting levels or processes of the brain. Damasio (1996: 69) gives numerous reasons for his position (a) One can loose the capacity to appraise the emotional meanings of certain stimuli without losing the capacity to perceive the same stimuli as an object. (b) The emotional significance of an object or event can be determined by the brain before we are conscious of perceiving it. We have seen that the amygdala can "know" whether some thing is good or bad before it knows what it is. (c) Memories of emotional experience are stored in brain mechanism which are different from those processing cognitive memories. (d) Systems involved in cognitive processing are flexible compared to emotional systems. Some call cognitive systems "promiscuous" because one can take an abstract position just to justify some action that they do not believe. A lawyer may do this for a client. Cognition in this sense is flexible.

Emotions are connected with brain systems which control behavioral responses and lack flexibility. It is possible but hard not to believe one's emotions.

It appears from the above that we need to know in detail in what sense emotions are distinct and in what sense they are integrated in transactional fashion.

(2) The next sin is to view emotions as subcortical. This would be true if they were independently seated in the limbic system, but they involve many cortical parts of the brain even in the amygdala when it takes its slow route that draws on the neocortex.
(3) Emotions are seen as being in the head. This is untrue for two reasons. They relate to the whole body especially through the visceral. Also, emotions are not self-contained like feeling; they relate to something. This is expressed linguistically through prepositions and is called "intentionality." Emotions are directed to something in the environment outside of its self. We have emotions about or at ourselves. Emotions contrast here with feeling because as much a little Sally has her emotional feelings hurt by the "mean" bee on her birthday, this sensual sting remains as a self-contained entity. Emotion sometimes dissipates when we learn some harm to us was unintentional. Sally can forgive the bee all she wants, but it will not take the sting away. Emotions (in the everyday sense) change as appraisal changes in contrast to sensual feeling.
(4) It is frequently held that emotions can be studied from a psychological perspective because feelings are conscious. But conservatively 95% of emotions, or brain activity in general, is unconscious and, in Damasio's point of view, have to do with continuing homeostasis which is unconscious.
(5) Another false belief listed by Duam et al. is that emotional circuits are similar in structure in both age and species. Emotions are not even the same in human girls and boys much less within different species. The differences in young women and men that do exist finally settle down until significant brain differences are few. For boys and girls the differences seem to be in their sequencing. Relevant to emotional development girls 2 to 3 years old could interpret facial expressions better than boys who were five.

An NIMH study (2007) concluded that understanding these difference means you are able to discourage stereotypes when girls are taught in the same fashion as boys. One would think that given the popular interest in gender differences in emotional expression, there would be substantial research in the area of brain-related aspects of emotional regulation. There is some fMRI evidence in gender differences in controlling reactions to negative pictures. Both men and women showed increases in prefrontal regions associated with appraising their reactions differently, but men showed less increases than women. Men also showed greater increases in the amygdala associated with emotional responding.

Relevant to emotional development girls 2 to 3 could interpret facial expressions better than boys who were five.

(6) The next false belief is that specific emotions are instantiated in discrete locations in the brain. Not even the limbic system meets this requirement. The cortex serves even the amygdala and we know little about the brain circuitry of the more subtle emotions.
(7) The last sin is to view emotions as conscious feeling states. This ignores much in neuroscience as this chapter has shown. This was true in William James' philosophy which has its virtues as a whole but has been rejected as technology in neuroscience has advanced.

A Critique of Hard Wired Primary Emotions. Kagan (2007) notes that there are some serious questions about the existence of primary human emotions. In his opinion, the belief that basic emotions exist which transcend history and culture is tenuous at best. A cultural and historical context selects a small number of emotions from a large number of possible emotions for that specific historical era. The emotions which are considered basic are defined by what is seen as salient in that particular culture and time. Traditional Japanese regard for "amae," an emotion experienced by those that place their complete trust in the nurture of another, was considered a basic emotion to them. For the early Christians put much value in "agape" as a fundamental emotion. But few people today know what it is. For those Christians it meant a self-sacrificing love from God that was to be reciprocated.

Primary emotions are considered the most basic ones that can be combined in various ways but not fundamentally altered (Averill and Nunley 1992). According to Kagan, an emotional state can change in its prevalence depending on historical conditions within a particular culture. The historical events that created bureaucratic, capitalistic economies with densely populated cities, and a diversity of values made a new emotion possible Kagan says. Sartre described it as "inescapable nothingness" and he might have added ennui.

Conclusion

We recognize that no satisfactory common thread is available drawing emotion into one common basket. Nevertheless one stands on solid ground in recognizing that emotion is necessary to balance the cognitive bias which still reigns in sociology and neuroscience (Franks 2006). Although we have not come to closure on a definition of emotion per se, we can view emotion generally as a very important residual category in the sense that it can be just what cognition is not. It may even be prudent to see emotions on a continuum from pure emotion to thought without emotion as in Damasio's "prefrontal" patients (Franks 2009 forthcoming.)

In Chapter 3 we summarized the implications of Tredway et al. (1999) neuroscientific reanalysis of the Spitz studies, which suggested another way the emotions precede thought – in this case developmentally. Emotions supply the ground, not only for human cognitive abilities but also for overall human functioning as well. Brain development requires information from the physical and social environment in order to correctly wire brain structures. During the first stages of infancy, the primary caretaker accomplishes the emotional shaping of the child. Since the so-called limbic system and brain stem are operational at birth, emotional development precedes and shapes the neocortex and thus the cognitive system. Tredway et al. (1999) go as far as to say that from an evolutional perspective, emotional processes are more important to survival than reason. This seems consistent with Turner's ontological thesis that emotion preceded gesture and speech. The phylogenic primacy of emotion was extended when the priority of emotional development to reasoning capacities and over all health was extended by the neurological work on child development. Regardless of Brothers views, it seems that LeDuox is on very solid ground in his belief that emotion organizes the brain.

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