Biomedical Correlates of Human Emotions

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Rene Descartes, the French philosopher credited with the awakening of Western philosophy post Aristotle had every eruditely remarked: "Humans differ from all other animals because they have a rational mind but resemble them when it comes to bodily passions which interfere with reason" [1]

Post Descartes we began to regard human emotions as legitimate mental states and began to invest animals with thoughts and feelings. It was Charles Darwin who suggested emotions as "states of mind" shared by both humans and animals. Emotions are understood as mental states felt when well-being is affected in some way. The emotion associated with being threatened is fear. Similarly, the emotion associated with matters going well is joy. The one associated with loss is sadness and the one associated with empathy for suffering of others in compassion.

Now that we have a general consensus that emotions are feelings, they have to be seen as states of consciousness which are normally inner individual experiences largely dependent on awareness of one's mental activity. Queries therefore automatically arise about scientific research on brain activity during different emotions in animals as well as human beings. There are obviously some very serious ethical barriers that come into the equation when one attempts to study the correlation between emotions and brain activity in humans. Much of the biological research in this area has emerged through animal research which has led to legitimate questions about its applicability in humans.

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The first half of the twentieth century witnessed the emergence of 'behaviourism' - a school of psychology which categorically rejected study of conscious experience instead promoting objectively measurable events for instance response to stimuli. Some behaviourists have regarded emotion as a brain state which connects external stimuli with responses.[2] This particular school tended to view brain states operating without any need for conscious awareness-separate from feelings - hence avoiding the queries about consciousness in animals. There were other behaviourists who suggested that human beings inherited emotional states of mind from animals and this was evidenced in the behavioural responses in the animal brains. Both these approaches have their own disadvantages. The first approach completely ignores conscious feeling which to many would seem to be central to emotion. Similarly, the second approach is based entirely on mental states in animals which cannot be validated scientifically.

When I embarked on my own journey in neuroscience research more than four decades ago, I began to favour a third approach different from the two I have just adumbrated and I must acknowledge a huge debt of gratitude to my mentors at the time viz. Max Hamilton and Merton Sandler. I tended to regard emotions as non-conscious brain states that linked significant stimuli with responses and feelings as conscious experiences from the non-conscious states of the brain. I regarded feelings as important but tended to believe that the central nervous mechanisms that control emotions and those that generate conscious feelings are different. This was not done to deny that feelings and multiple states of consciousness existed in animals but to concentrate on researches that could be validated scientifically independent of the final outcome of the debate on animal consciousness. As feelings are essential in psychiatric disorders that afflict human beings, conscious feelings should be studied in humans.

Although this strategy was useful at the time, there was always some unease about the dichotomy between

emotion and feeling; after all the latter is only the conscious experience of the former. One of the problems with this approach was that the terms 'emotion' and 'feeling' are used interchangeably not just in the colloquial circles but even within the scientific community. To deal with this problem, I had to rethink the everyday usage of these terms. And this inevitably propelled me to study the natural history of what is normally understood as emotion in animals. I then began to understand that the term emotion is deeply linked to conscious feelings.

Emotion of fear is an example. To study fear and its underlying brain mechanisms, we study Pavlovian conditioning. Human studies have confirmed that roughly the same brain areas are affected in threat conditioning as they are in rats.[3] We know how the regions and sub-regions of amygdala involved in receiving the tone and shock, bringing about their integration and store a memory of association and use that to construct defence. The present state of technology does not enable us to study regions and sub-regions of amygdala at this time but it can safely be inferred that neural circuits in humans and rats are likely to be similar as they perform similar functions in rodents and humans.

Most interestingly Pavlovian threat conditioning has also been noted in invertebrates where the neural circuits are entirely different. [4,5] And it is also noteworthy that molecular mechanisms involved in intracellular signalling and gene expression in invertebrates have subsequently been confirmed in rodents. Therefore, there is every reason to believe that they would similarly apply to mammals.

As mentioned earlier, detailed brain mechanism studies are not possible in humans. But we do know that when threatened, humans have an autonomic nervous system response that anticipates the threat and prepares the body for a response. We also know that the amygdala is activated.[6] The person may experience trepidation but that does not necessarily imply that it is the same brain circuits that generate this fear. For instance, the amygdala is activated and responses are noticed in subliminal presentations of threat. I have always believed that all animals have the capacity to detect fear and construct responses-but only those animals that are conscious of their brain activity can experience fear.

In humans, many of the survival mechanisms are associated with feelings. But the neural circuits that regulate the survival process functions quite differently to the ones that govern feelings.[3] It is therefore understandable why problem of understanding feelings is intricately related to the problem of understanding consciousness- and consciousness is something that cannot be observed.

Michael Gazzaniga earned himself a substantial reputation for his researches on patients in whom nerve connections between two sides of brain are severed to treat epilepsy.[7] Many of his researches provided us insights into the workings of the brain and mind. Gazzaniga on the basis of his findings inferred that "consciousness was an interpreter of experience by which we develop a self-story that we use to understand those motivations and actions that arise from non-conscious portions of our brains." He believed that a large part of our actions is governed by the non-conscious process which we only understand when we interpret their expression either in other parts of body or behaviour states.

There has been a recent upsurge of scientific interest in consciousness in the last two decades. Much of this is attributable to our enhanced understanding of the conscious perceptions of visual stimuli.[8] There is a general consensus at present that we are not conscious of representations in the primary visual cortex i.e., the part that first receives the visual stimuli. There are some who believe that later stages of visual cortex create our conscious visual perceptions. There is another school that believes that visual cortex is not sufficient to invoke conscious visual phenomenon and additional neural circuits are required. There are a number of cognitive theories that lay stress on attention and working memory in consciousness.

It does seem reasonable to infer that human emotions are conscious experiences when directed by attention process about the operation of non-conscious phenomenon to working memory. A very important part of non-conscious phenomenon is associated with the recognized survival functions which I have mentioned earlier. Instances of these survival functions are energy management, thermoregulation, reproductive functions and fluid balance. Hence the brain circuits that regulate these activities are known as survival circuits. [9] We are entitled to wonder whether it is the operation of survival circuits that initiate the conscious feeling that we perceive as fear. Such motivational states occur not just within the mammals but other vertebrates and even in some invertebrates e.g., slugs, worms, bees etc. All organisms are equipped with mechanisms that help them withstand and survive threats.

This defensive circuit affects the behavioural and cognitive functions.[8] When we perceive danger, we become hypersensitive to any stimulus we associate with danger. Experiencing trepidation therefore is a factor that promotes survival but it is certainly not the most common response as it only occurs in living organisms that can be conscious that they are in danger. We can definitely state that human beings do fall into this category but for obvious reasons drawing such inferences within the other organisms would be difficult. Therefore, the presence of a motive state and emotional behaviour is not synonymous with the presence of a conscious feeling. For a conscious feeling to occur, the nervous system of the organism has to have the capacity to experience the motive state. My own position is that the motive state is cumulative response of the brain to the activation of the survival circuit. Defensive responses therefore contribute to defensive motive states -not the other way round. Another conundrum that has to be negotiated here is whether the motive state can itself contribute to feelings that are conscious by making inroads into the working memory or whether the working memory is itself a coordinate of individual neural components that which constitute the motive state. That question is yet to be satisfactorily answered.

Charles Darwin had postulated that humans had inherited very hard-wired circuits from the animals during the evolutionary process.[2] These circuits are survival circuits and their function is to identify situations and regulate behaviours that can assist us in withstanding life's challenges as well as make the most of the opportunities that are made available to us. It was a revolutionary idea at the time but we now know that Darwin was in error when he stated that we inherited states of mind e.g. trepidation from other organisms. Survival circuits that are found in the subcortical region of the brain are not inherited reservoirs of feelings. Rather feelings are almost parasitic when it comes to the capacity for conscious awareness which owe their provenance to only the cortical circuits.

My erstwhile neuroscientist colleague from Scotland, Gordon Arbuthnott and his colleagues have attempted to explain how brain makes feelings by drawing an analogy with making soup. I shall reproduce the paragraph that appears in his book:

"To understand how the brain makes feelings, consider an analogy to cooking soup. Salt, pepper, garlic, and water are common ingredients in many if not most soups. Put in chicken and it suddenly by definition becomes chicken soup. The amount of salt and pepper can intensify the taste without radically changing the nature of the soup. You can add other ingredients, like celery, turnips, or tomatoes, and still have a variant of chicken soup. Add roux and it becomes gumbo, while curry paste pushes it in a different direction. Substitute shrimp for chicken in any variant and the character again changes. None of these are soup ingredients per se; they are things that exist independent of soup, and that would exist if a soup had never been made. Similarly, emotional feelings emerge from non-emotional ingredients. Specifically, they emerge from the coalescing of non-emotional ingredients in consciousness. The particular ingredients, and the amounts of each, define the character of the feeling. The pot in which feelings cook is working memory." [10]

A motive state that is defensive contributes many components of what we perceive as fear. There is a very direct input from the amygdala to the brain cortex which leads to arousal of the central nervous system leading to body feedback resulting in the goal directed behaviour.[11] The information related to these activities is then coalesced into working memory along with details of the external stimulus. We can feel alarmed or concerned or panic; this would depend upon the characteristics of the factors stimulated in the brain, information about the stimulus and physiological factors in the body.

Emotions also result from motives that are non-conscious. Feelings of shame, compassion and pride fall into this category. Other examples are failing in life and facing death. These emotions frequently do not result from a motive state which depends on external stimuli. [11]

If we seek to understand the enormous complexities of the nervous system associated with the emotions and consciousness e.g. joy, sadness and anger, we would have to gain an understanding of how non-conscious and non-emotional components are organized within the brain. We can draw some very meaningful inferences once we have a proper understanding of the non-conscious and non-emotional constructs and how they impinge upon or conscious feelings. As humans share this attribute with other animals, there is a good case to study these processes across different species -even in those where there are major doubts about the existence of the conscious phenomenon.

Whether or not non-human organisms have feelings is contingent upon whether they have the mechanisms to enable them to be conscious of their own

brain states. This is a highly complex conundrum that in all probability is not going to be satisfactorily resolved within the lifetime of retired and lapsed neuroscientists like myself. But there are very few arenas of biomedical research that offer comparable challenge and excitement than this. We still have an enormous lot to learn about human consciousness and emotions through researches on brains of humans as well as non-humans.

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