Biomedical Correlates of Consciousness

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Francis Crick, the ace biomedical researcher, who is commonly credited with the double-helical structure of the DNA, was also responsible for his stellar work on the role of the central nervous system in regulating human consciousness. As opposed to his work on DNA in which he collaborated with a number of colleagues, and which lasted for less than a decade, Crick spent more than four decades attempting to unravel the conundrum of consciousness. [1] One of his early collaborators was the Indian biochemist B.K. Sur, who eventually returned to India and was one of my teachers in the medical school where he headed the Department of Biochemistry. A large proportion of activity that takes place within our central nervous systems happens below the level of consciousness and many of our intuitive insights about unconsciousness are faulty, consciousness has by and large remained elusive even today and whatever little insight is available to us is in a very large measure the result of this pioneering researchers efforts.

It was Professor Sur who once narrated an anecdote about Crick that I still remember very vividly. Crick had once shared with him that when he was about 14, his mother had once posed an interrogatory to him. She had noted his scientific bent of mind and asked him about the scientific enigmas he was most interested in unraveling. The young teenager had told her that he was only interested in two problems: the enigma of life and the enigma of consciousness. It was in 1953 that Crick and his associates were able to present a groundbreaking discovery that substantially enhanced our understanding of life. He then relocated to California to dedicate himself to unraveling the mystery of consciousness as he had mentioned to his mother as a teenager.

Dr. Ashoka Jahnavi Prasad is identified as the most educationally qualified person in the world by The Polymath. He has a dynamic resume with a PhD in history of medicine from Cambridge, LLM from Harvard among other notable qualifications. Dr. Prasad has also worked as a consultant to the World Health Organization (WHO) and helped prepare two of their reports.

Francis Crick's Groundbreaking Work on Consciousness

He decided to concentrate on visual awareness as the understanding of the functioning of the visual cortex was better (in the mid-1970s) than the other perceptions. He was very fortunate to have procured the support of two of the leading neuroscience researchers of that era viz. V.S. Ramachandran, who was based at the University of California in San Diego, and the ace physicist Gordon Shaw. It was an offbeat area of research way back in the late 1970s and the early 1980's but that did not serve to deter these committed students of science. Visual perceptions at the time were filled with illusions and mysteries because of improper understanding. They attempted to link them with anatomical and physiological processes.

In the beginning, he proposed a "spotlight of attention" hypothesis.[2] By that time, it had been accepted that the ganglion cells in the eye i.e. retinal neurons which encode patterns of light on the retina and convert them into patterns of spikes, generally project through the optic nerve to the thalamic area of the brain. This in turn relays the spikes to the visual cortex. When he proposed this hypothesis at the Salk Institute in *La Jolla*, he was asked to explain why did the ganglion cells not project directly to the cortex. This of course was a valid question to which Crick responded by stating that there was a feedback projection from the cortex back to the thalamus which akin to a spotlight may be in a position to highlight portions of images for further processing. This meant an attempt to find correlations between the firing capacity of the neurons in the different parts of the brain and visual perceptions.[3]

One of Crick's ideas was that we are generally not aware of what takes place in the first area of the cere-

bral cortex i.e. the primary visual cortex. Instead, we are only aware of the results of processing at the highest level of hierarchy in the visual area. This is supported by the contention that in binocular rivalry, when two different patterns are presented to the two eyes, one does not see a blend of these images but visual perception flips and oscillates between them every few seconds. Neurons in the visual cortex of course respond to both the patterns irrespective of which pattern is being perceived at that moment and time. But in the higher levels of visual hierarchy, a much larger fraction of neurons respond only to the perceived image.[3]

About eight years ago, a classic experiment was conducted at the University of California in Los Angeles. Few patients with seizures consented to have their brains monitored. He was shown a series of snapshots of famous celebrities. Electrodes that were implanted in his memory centre reported spikes in response. Interestingly it was observed that in one of the patients, the response was very vigorous when he was shown a snapshot of a very famous female actress but not to the others. This added weight to the contention that in the hierarchy of the visual areas of the cerebral cortex, the response properties were more specific. This can only suggest that the process of recognition which was hitherto thought to be passive actually depends on the very active engagement of memory and attentional control.[4]

Neuronal and Cortical Activity Governing Consciousness

The next question the neuroscientists had to tackle was how many neurons were needed to discriminate between two similar objects e.g. identical twins. Imaging studies have demonstrated that many areas of the brain respond to human faces and some of them have a very high degree of selectivity. There have been suggestions that there are minimal number of neurons in the representation of an object.[5]

A very important aspect of visual awareness is the brain's efforts to register events e.g. flashing traffic lights which only occur at specific times. The usual time delay of the visual cortex neurons in response to a visual stimulus is between 25 to 100 milliseconds. But most of us are able to make out two flashes that occur within 40 milliseconds of each other.[5]

It is the coordination between different perceptions which presents us with a major problem. Light travels much faster than sound. Yet when we observe someone chopping down a tree, we immediately perceive the sound of the axe as soon as we see the tree being hit by an axe. Clearly, the spontaneity we observe is an illusion but it does provoke a reaction in the cortex.

Experimental neuroscience has provided us evidence that we only become consciously aware when the brain activity in the cortex reaches a certain threshold and starts igniting feedback pathways. Not that long ago, neuroscientists harbored a belief that visual senses were completely separate from the other sensory processing streams. We now know this not to be true. The visual system actually integrates information from the other streams Subsequently the motor system utilizes this information to reposition sensors to perform a task.[6]

Francis Crick helped us with the structure of the DNA in 1953. The Human Genome was mapped five decades later. One is tempted to wonder where would we be in another five decades in our understanding of consciousness. There may be robots available in the future that can interact with us in every possible manner. It may be that we may be able to create 'consciousness' without even fully understanding it. There are still many unanswered and vexatious questions that we still have to work on. Perhaps I can venture a suggestion that we commence by attempting to fully understand unconscious processing. This would include countless things we take for granted and do not spare a thought. We are at the stage when although still insufficient, we do have some insights into our attentional systems which help us obtaining information and motivational systems which can influence our decisions. It is essential that we redouble our efforts to get a deeper understanding of the central nervous system which after all governs decision making, planning and perception. That would enable us to unravel the many mysteries of consciousness that Crick had identified in his teenage.

References:

1. Crick F. What Mad Pursuit: A Personal View of Scientific Discovery. New York: Basic Books; 1988.
2. Crick F, Koch C. The Problem of Consciousness. Scientific American. 1992;267(3):10-17.
3. Crick F, Koch C. Are we aware of neural activity in primary visual cortex? Nature. 1995 May 11;375(6527):121-3.
4. Quiroga RQ, Fried I, Koch C. Brain cells for grandmother. Sci Am. 2013 Feb;308(2):30-5.
5. Deisseroth K, Schnitzer MJ. Engineering approaches to illuminating brain structure and dynamics. Neuron. 2013 Oct 30;80(3):568-77.
6. Eagleman DM, Sejnowski TJ. Motion integration and postdiction in visual awareness. Science. 2000 Mar 17;287(5460):2036-8.