Electric Sheep

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Dr. Ramachandran's great success in his book, *Phantoms in the Brain* is showing that a logical explanation exists for several seemingly irrational human conditions, anywhere from the perception of non-existent body parts, mistaken identity and hallucinations to religious experiences and explores the nature of consciousness. It becomes evident that the brain is not merely a mass of jumbled up neurons that randomly fire at each other. Instead, the human brain is a complicated organ with several discrete, highly specialized structures, which serve very specific roles in perception, memory, thought and consciousness. Several patterns of behavior can be linked, consistently among patients with similar symptoms, to malfunctions in various areas of the brain.

It was the discrete, modularized nature of the brain, illustrated in this book that fascinated me the most. If we are eventually able to map every human behavior to a corresponding part of the brain, the possibility arises that we could make mathematical models of these discrete structures, simulate them in software or even replicate them in machinery. Following some key topics in *Phantoms in the Brain,* I will explore some of the possibilities that may arise from future research and development of key technologies in relation to neuroscience and cognitive science.

Phantom Limbs

The term "phantom limb" is used to describe the sensation that one might feel after losing an arm or a leg, yet still feels the arm or leg as if it where still attached to their body. Every part of your body that you feel has a sensory input that can be traced back to an area along the surface of the Cerebral Cortex. A model called the Penfield-Homunculus ("little man") exists to represent this map of sensory input in terms of body

parts of a small man draped across the surface of the brain. If a body part, for whatever reason, becomes detached from the body, the sensory input from the body part no longer exists but the neurons connected to the body part still exist and are capable of receiving sensory input.

The phenomenon of phantom limbs exists because neurons connected to those of a non-existent body part are activated by neurons in close proximity that receive sensory input. Take for example, the classic scene in the movie "All Quiet in the Western Front", the man is lying in a hospital bedroom with an amputated leg, only after he looks down does he realize that he no longer has a leg, because until he had visual feedback, he felt his legs, more specifically that area of his brain was still receiving sensory input from the surrounding neurons, and for all he knew, some of that input was coming from his leg.

What if, for example, a person experiencing a phantom arm were to replace the missing sensory input with artificial signals generated by a computer, and the arm replaced by a robotic equivalent? Just as sensory input can be recorded and manipulated, neurons that send the signals that cause the limbs and body parts to move can also be monitored. The output from these neurons could be processed and translated to movement of the robotic arm, with simulated sensory input to provide feedback. At the very least, the output of the neurons could be recorded in software and analyzed to interpret actions, which could be translated into other types of information, like control signals for an electric wheelchair or remotely controlled machinery.

Currently The National Aeronautics and Space Administration, has tremendous research interest in remotely controlled robots to replace mans role in space walks. Specifically, a Project called Robonaut

(http://vesuvius.jsc.nasa.gov/er_er/html/robonaut/robonaut.html), from the Johnson Space Center consists of two arms, dexterous hands and what appears to be a head, for visual feedback all in proportion to the human body. This biologically inspired robot is controlled remotely using a virtual reality helmet and a series of sensors along the arms to monitor movement. Interacting with a robot in such a way is inefficient, in that there is a significant delay associated with moving ones arm and having the robot replicate the movement. Feedback in such a scenario is also limited to the visual system and at the very most pressure sensors that can be read remotely to determine whether or not the arm is exerting too much pressure or not enough. Assuming it were possible, some day in the future, to monitor neuronal activity and accurately translate actual arm movement into simulated arm movement and provide sensory feedback, robots like Robonaut could benefit.

Forgotten Future

As is depicted in the recent movie "Memento", it is possible to completely lose the ability to form new memories. The hippocampus, part of the limbic system is responsible for moving short-term memories into long-term storage. The term "anterograde amnesia" is used to describe the loss of the ability to form new memories and such problems are linked, consistently, to damage to the hippocampus.

Dr. Ramachandran uses the example of H.M to illustrate the role that the hippocampus plays in forming new memories. H.M. suffered from epilepsy and to cure H.M., his doctor removed his hippocampus. With the loss of the hippocampus, H.M. could remember everything that happened to him before the surgery and nothing that happened after the surgery.

Scientists are investigating the possibility of replacing a missing or malfunctioning hippocampus with an artificial, functionally equivalent prosthetic in rats. Because the hippocampus is highly ordered, well structured and provides a very specific function it is relatively easy to test and simulate. Scientists have studied the hippocampus, made a mathematical model, studied the model under all possible conditions, built the model into a silicon chip and interfaced the chip with the brain. The scientists will soon test their chip on rats and later monkeys. The success of their research will be determined if the rats and monkeys are able to form new memories after their hippocampus are bypassed with the mechanical equivalent.

Fortunately, the hippocampus is similar, structurally and functionally in most mammals and a successfully tested and proven prosthetic hippocampus in a monkey could be adapted for use in humans. Ethical questions aside, a prosthetic hippocampus could restore the ability to form new memories in patients who suffer from anterograde amnesia due to stroke, epilepsy, alzheimers, chronic alcoholism and physical trauma to the brain.

An artificial hippocampus could have some interesting applications in science not-so-fiction. Imagine the possibility of forming false memories through a remotely connected hippocampus. Could it then be possible to share memories and experiences with others? Taking it to the extreme, there would be no need for friends, family, health, social interaction, sex, drugs, music, entertainment, individuality, flavor or anything that makes life worth living when the perceived memory of such can easily replace their real-world counterparts. Or, imagine a Big-Brother-esque (Orwell) world where instead of

communicating to the masses with ever-present telescreens, memories could be implanted, history could be changed and minds controlled.

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There is nothing we know more intimately than conscious experience, but there is nothing that is harder to explain (Chalmers). With time, I believe it to be possible that we, as a species will see a complete, inorganic, functionally equivalent mechanical brain. Philip K. Dick poses the interesting and thought provoking question, do androids dream of electric sheep? The real question that must be answered when this is all said and done is whether or not a human brain that is completely replaced, piece-by-piece by mechanical equivalents will gain consciousness and where do we draw the line between man and machine.

Dr. Ramachandran, in the end of "Phantoms in the Brain", explores the nature of consciousness and says that the very definition of consciousness is free will. The nature of consciousness and the question of free will has been explored throughout history in every culture and is a deeply philosophical question that we could not begin to answer without fully understanding how the brain works. Dr. Ramachandran suggests that the next hundred years will be the golden era of neuroscience as we begin to understand more the human brain.

Ray Kurzweil in an article entitled *The intelligent Universe*, suggests the possibility that the human brain will be completely reverse-engineered within 25 years. Perhaps one day we will be able to answer the electric sheep question.

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