Future Brains

An Exploration of Human Evolution in the 21st Century and Beyond

by Arthur Saniotis

Introduction

The evolution of *Homo sapiens* has been one of the most fascinating experiments this planet has ever witnessed. Some 2.5 million years ago our early human ancestor *Homo habilis* started to use tools, which began a new kind of evolution informed by technology. The escalating use of tools and discovery of fire expanded the social and technological potential of the species *Homo.* The emergence of agriculture-based societies eventually gave rise to stratified civilizations, fostering further technological advancements.

Human evolution is unique in that it has been able to make substantial evolutionary leaps which, in Stephen Jay Gould's words, correspond with the notion of "punctuated equilibrium" (1972, 1977). Punctuated equilibrium offers a poignant explanatory model for understanding the rapid evolutionary changes of the human species. Such transformation is posited on a 'conscious design' which has supplanted natural selection (Stock 1993). As a result, the human species is the first and only species which is now capable of tinkering with its own evolution. The human brain, with its dependency on symbolic thinking,affords an unlimited range of behavioural possibilities, which continue to inform human evolution, and has now placed human beings in a position "to guide the future course of evolution on earth towards greater fulfillment, so as to realize more and higher potentialities" (Huxley 1962). In this paper, I will explore future possibilities in human brain evolution. The first section will discuss new cognitive possibilities,. the second will examine the cyborgisation of the future brain, and the third will explore nanotechnology and virtual realities. My aim is to inform the reader of potentialities which may be available to human beings in the not too distant future. The growth in new biotechnologies will potentially have a transformative effect on the human species. However, where this evolution will take us is still unknown.

Future Evolution and New Cognitive Possibilities

The human brain is the most complex structure in the known universe, composed of some 100 billion neurons. Each neuron has at least 10,000 synaptic connections, which proffers approximately 1,000 trillion neural connections. The sheer scale of the neural network has endowed humans with a consciousness that is unparalleled in the animal kingdom. Edelman (2006), has shown that the brain works in neu-

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ronal groups which are adaptive and selective — a process which he calls “neural Darwinism”. The brain, thus, is seemingly driven towards negative feedback loops which enhance neural interconnectivity. What is important here is that neurons do not act alone, but co-operate in groups. Goodwin quoting the neurophysiologist C. S. Sherrington, describes the brain as “an enchanted loom, where millions of flashing shuttles weave a dissolving pattern” (Sole and Goodwin 2000). For Gregory Bateson, the brain is designed with a bias towards meta-patterns, which are prevalent throughout nature and which mirror the mind’s architecture. As a self-organized system, the brain is designed for producing novelty.

It is this novelty-producing aspect of the brain which is significant for its future evolution. According to Eugene Thacker, we live in an age of remediation of the body and are on the verge of brain remediation via brain chips (which will be discussed in the next section). Brain remediation is an aspect of embodiment. Second, the brain is framed and mapped by scientific and medical knowledge. In this way, the brain is an on-going project which is being disclosed by biomedical technologies. Future sciences will be mainly concerned with re-engineering the body. Redesigning the body and brain will constitute a way of redefining them. The brain, like the body, will probably be understood in medical discourse in two ways; firstly, as a biological organ, and secondly, as an organ for technological modeling (Thacker 2004). The future brain will be at the nexus of biomedia — a set of technology-based techniques and knowledge (Thacker 2004). Importantly, future sciences will involve a series of technological processes for optimising human biology (Thacker 2004). The metaphor of the brain will itself be reconfigured to a point where what is technological will enframe what is biological (Thacker 2004).

According to Stephen Hawking, making humans smarter is essential, if we are ever to travel to the stars. The present state of cranial development is stymied by the limited nine-month incubation period, which restricts cranial development, in order for the foetus to pass through the vaginal tract. Hawking’s solution is to develop a simulated uterine environment which will allow for a longer gestation period, and therefore, permit increased encephalisation. Various chemicals added to these uterine environments would promote optimal brain size and facilitate computer links to further stimulate brain development. In the movie *Superman* [1978], the extraterrestrial child incubates in a womb-like space craft. During its voyage, the child grows and develops physically and mentally. In future, such uterine simulations may be designed to cater for a new race of intellectually superior humans. Charles Laughlin claims that the intra-uterine environment may in fact be a nascent educative arena. A major reason is that 50% of brain development occurs during the pre and peri-natal stages of life — “between conception and six months of postpartum infancy” (Laughlin).

Cyborgisation of the Future Brain

According to Laughlin (1996a), the cyborgisation of the human being will involve the transformation of the brain’s organisation. This future process will require the penetration of the human brain by technology. While Laughlin stipulates four stages of “exogenous technics” the fourth stage is of special interest here, as it proposes a true machine/mind interface — specifically, the brain would be modified by an array of bio-chips which will mediate cognition and emotion (Laughlin 1996a).

The emergence of the cyborg is a process of progressive technological penetration into the body, eventually replacing or augmenting the structures that mediate the various physical and mental attributes that we normally consider natural to human beings.… Clearly then, progressive penetration into the cortex of the brain will inevitably result in the technical alteration of human consciousness (Laughlin 1996a).

Such an alteration in human consciousness may be a necessary adaptive mechanism for long term space travel. The present stage of brain development has evolved in response to environmental pressures in the African savannah when our ancestors lived in small groups as hunter/gatherers. Therefore, it is likely that our existing brains will prove unable to psychologically cope with the exigencies of long term space travel, which might require many generations of humans to live in a space ship environment (Shostak 1998).

Brain/machine interfaces (BMIs) would be posited on bio-feedback between neurons and bio-chips and driven by neuronal electrical impulses (Nicolelis 2003). The range of application for BMIs would be considerable, from restoring motor functions to paralysed people to military virtual reality training (Nicolelis 2003).

Brain implants would slowly be enveloped by converging neural clusters after a few weeks. Growth of neural connections and higher cortical structures continues after adolescence, raising the question as to when the human brain can be optimally interfaced with A.I. components (Laughlin). These brain implants would contain trophic factors that would attract neurons towards them (Greenfield 2003). Moreover, such implants would facilitate the creation of virtual realities — a process of hooking up the brain to a computer which would provide the user with alternative experiences perceived as real — a cyber-world that taps into the physical senses (Greenfield 2003). Cyber space or holographic worlds could link up to experiences and sensory perceptions, conferring the recipient with an experience of being on anywhere earth. It may be that such earthly experiences play a vital part in space travel to alleviate space sickness and the psychological consequences of enforced separation from the earth for extended periods.

For Charles Laughlin, the cyborg/brain interface should start at a young age during brain growth in order to achieve optimal cognitive development. "Growing into one's cyborg nature" will be important to the maturation process in order to be able to discriminate between real and virtual worlds (Laughlin). Alternative sensing devices such as infrared visual cortex devices and auditory devices which act outside the normal range of human seeing and hearing would augment human sensory experience (Laughlin). The cyborg's stream of consciousness would therefore be different from the consciousness of ordinary humans. As Laughlin asserts, "The cyborg will experience weather in a far more global way than the rest of us are capable." In order to facilitate in this cyborg interface in young people, neural structures must be targeted during early childhood and adolescence, a period of active development and training of those brain cells that enablelearning and decision making (Laughlin). With the establishment of an AI interface, children can be guided to "socially controlled … cyberspace resources" (Laughlin).

One area of AI interface will be the availability of "ideology chips" designed to augment intelligence. Such chips could be used to solve or correct a range of behavioural and developmental problems in children such as attention deficit disorder and dyslexia (Laughlin). Ideology chips and other cyborg interventions will be generally accepted, since they are most likely to arise in cultures which privilege success and competition. Such interventions will probably concentrate on early childhood, in order to optimize neural development. However, such augmentation of neural networks may lead to "uneven maturation" (Laughlin). There is a likelihood that cyborg children will have greater emotional stress since there will be greater pressure on them to perform cognitively at a level beyond ordinary children.

Equilibration within an unhealthy sociocultural milieu may be reached at the expense of psychopathology — and perhaps psychopathological patterns of a type heretofore not experienced by the normal human psyche. (Laughlin).

In all probability, cyborg technologies will challenge the distinction between culture and nature (Strathern 1995). The biological and cultural structures which facilitate human enculturation will be transformed. We do not know how this will effect socialisation, its processes and methods. For example, Kroeber (1920) points out that neurosis tends to increase in populations in which mythic structures which otherwise inform the human psyche decrease. Human well-being is therefore not the sum of cognitive excellence, but a result of biological, experiential and social factors which contour the human being to working as an integrated whole. Those quantitative based societies in which cyborg technologies will likely emerge are already characterised by high rates of mental illness and will probably need to confiture special programs for cyborg children that take into account their moral and social development.

Nanotopia and Virtual Worlds

The subject of nanotechnology has received considerable attention from many futures thinkers. One of the most prominent of these is Ray Kurzweil, whose book, *The Age of Spiritual Machines* (1999), discusses nanotechnology as a kind of future holy grail which will transform the world. One of the advantages of nanotechnologies will be their capacity to morph objects at a molecular level. In the same way, Kurzweil predicts that it will be possible to reconfigure biological cells such as brain neurons in order to create nanotech neural pathways. Kurzweil's interest in building new nanotech brains stems from his concern about present brain development. For Kurzweil, evolution is far too slow and unreliable a process, especially in the area of cognitive development. Furthermore, the human brain, albeit a parallel processing wonder, is too slow for Kurzweil (1999). Take for instance the following: "Today, our software cannot grow. It is stuck in a brain of a mere 100 hundred trillion connections and synapses. But when the hardware is trillions of times more capable, there is no reason for our minds to stay so small" (Kurzweil 1999).

Kurzweil's answer is to rebuild the brain, atom by atom. Such a nanotech brain will no longer be dependent on biology. Additionally, nanotech brains will have augmented intellectual and sensorial capabilities. How augmented, we can only speculate. What we can surmise is that such a brain will probably have a different kind of consciousness. The nanotech brain will be unlike its biological counterpart. Will this be a beneficial thing? Again, we can only speculate. Our biological brain has been shaped by millions of years of evolution. The cultural processes which inform mind from the onset of life are both complex and ongoing. The nervous system with its sympathetic and parasympathetic systems are designed to be stimulated by symbolic and environmental phenomena. For example, human empathy with other animals may derive from the pleasure centres of the cerebral cortex — which are seemingly universal in the mammalian world (De Waal 2008:34). The process of neural empathy is increased by exploring multiple realities by the individual (Laughlin 1996b). What is important here is that the brain is structured by a polarity between adaptation and maintaining its own integrity (Laughlin 1996b). The cerebral organisation of the brain is determined by "genetically determined properties" which Laughlin refers to as neurognosis (Laughlin 1996b:7). Neurognostic structures are composed of neurons which battle against each other in "topographical competition" (Edelman 2006:83). This has an indelible effect on the brain's neural wiring. For both Laughlin and Edelman, this means that neural pathways are constantly reforming based on social experience. There is some doubt whether a nanotech brain would follow a similar neurognostic structure of competing neurons which fashion experience. Secondly, a significant factor of the brain's neurognosis is that it is capable of experiencing multiple phase states — non-ordinary states of consciousness such as dreams, visions, and various induced and non-induced trance states (Laughlin 1996:9). Would a nanotech brain be capable of experiencing the same "multiple phases" (Laughlin 1996b), which now influence human experience and cogitation?

Kurzweil notes that in our efforts to understand mental states we are able to draw upon our emotional, intellectual and spiritual experiences (1999). The nanotech brain will allow us to experience a utopian life style free from mental illness, psychosis, fear and anxiety. Synthetic nano designed neurons implanted in the brain could exponentially increase the brain's parallel processing while providing direct links to the internet (Dinello 2005).

Nick Bostrom has predicted the possibility of downloading mind, which consists in replicating the brain "molecule by molecule, scanning off the neural network," "and then running an emulation of the neural configuration on a computer" (Bostrom 2000). Bostrum asserts that a mind downloaded onto a silicon chip or "mind file" will possess the personality and memories of the organic person (Dinello 2005). Furthermore, people could generate back up copies of their mind simulations, thereby endowing themselves with immortality since these could easily outlive the biological body (Bostrom 2001). Dinello claims that while ensuring one's immortality, being entrapped within a computer simulation may become a kind of enslavement — a shadow existence far inferior to their biological lives. Here, Kurzweil (1999) replies: "People will port their entire mind file to the new thinking technology. There will be nostalgia for our humble carbon based roots, but there is nostalgia for vinyl records also."

Creating mind simulations from organic brains will be challenging since it calls for emulating the complex neuronal matrix. With advances in virtual reality, computer simulations will become more efficient (Bostrom 2003). Nanotechnology will be crucial in this development. For example, the estimated efficiency of a planetary computer is in the range of 10^42 operations per second (Bostrom 2003). Such a computer could contain all the knowledge obtained throughout the entire course of human history using "less than one millionth of it processing power." (Bostrom 2003). A post-human civilisation would probably possess a multitude of such super computers thus enabling virtually limitless cognitive tasks and neuroscientific possibilities.

In his essay titled, "The *Homo Cyber Sapiens,* the Robot *Homonidus Intelligens,*" Luc Steels describes future humans as having augmented brain capacity via computer interface (Steels 1995). This human/computer interface will bring human beings to a greater understanding of the origins of human intelligence and the mechanisms of evolution which are directed towards the formation of consciousness (Johnston 2002).

The neuroscientist Susan Greenfield offers an alternate view in which humans live in a futuristic virtual reality. Based on the ideas of the physicist Freeman Dyson, future humans will engage in neurotelepathy which is facilitated by the interface of electronics and the human brain (Greenfield 2003). Input from the outside world would be intercepted by cyber-network and tapped into the sensory perceptions. "By fabricating a cyber-world that taps into the senses, which then work in the usual way, neurotelepathy might have far more purchase on our minds" than the intrusion of brain electrodes (Greenfield 2003). Greenfield envisages that in the twenty-first century neuroscience along with molecular engineering will work in tandem to form novel versions of neurotechnology which will manipulate and probe with precision areas of the brain with long term ramifications for future life (Greenfield 2003). This will be a driving force of the "neurotechnological age" (Greenfield 2003). The "neuronal landscape" (Greenfield 2003) — particularly the cerebral which governs human consciousness — will be slowly uncovered. The more the brain's dynamic neural circuitry is disclosed, the human ability to tamper with brain and mind will become a possibility (Greenfield 2003).

For Greenfield, the future world will be a "mentally networked society, a trend which is apparent in modernity's dependence on cybernetics. In the future machines will play an intrinsic role in human sociality and cerebrality" (Greenfield 2003). Here, Greenfield surmises that machines will enable human beings to gain a more informed understanding of human consciousness. However, the future world will increasingly blur reality and fiction, to form a virtual world. The present breakdown of traditional kinship structures will be supplanted by virtual relationships over the internet. People may also be able to create friendships with imaginative entities — fictional characters with fabricated histories (Greenfield 2003:244). Fabricated relationships may be an ever present and acceptable phenomenon in a future virtual world.

In addition, Greenfield's future world of sophisticated machines would render obsolete present notions of autonomy. The satiation of bodily desires via neural and transgenic technologies will ensure that human beings are not only kept in a state of indifference to their external surroundings, but that the virtual world will be the preferred medium of participation (Greenfield 2003). In a world increasingly dominated by "ubiquitous computing: our grasp of 'reality' and our notion of a stable, consistent 'out there' might start to disintegrate," and human beings will live as "passive recipients" of an impersonal cyber network (Greenfield 2003).

Conclusion

These are only some of the possible future directions of brain evolution. It should be remembered that the brain is an ongoing evolutionary project due to its neural plasticity. The wide range of human cultures, cosmologies and belief systems are emblematic of the plastic nature of the human brain. A number of futurists have written about possible brain enhancements, including entire cerebral reconfigurations. Present discoveries in bio- and nano-technology may in fact spurn on the particular developments outlined in this paper. I am reminded of Stewart's notion of consciousness and evolution where he says that, at the onset of an organism becoming conscious of its evolution, "its evolvability" may be able to improve (2000). Human beings have developed a capacity to pursue their own "evolutionary objectives" — a kind of "evolutionary self-management" based on a revolutionary modification of their organic hardware (Stewart 2000).

In remodeling the brain, we need to be aware of its long evolution and its bio-genetic drivers that mediate experience. Perhaps our current future visions of new and vastly improved brains reflect our preoccupation with control. In fact there exist "zones of uncertainty" coining Laughlin (1996b) which represent a mystery and the greatest challenge for human beings. The complex patterns of neurons which are the architecture of consciousness make the brain into a mystical structure. The brain "is embedded in the quantum sea" (Laughlin 1996b). In other words, "The brain is prepared by virtue of its neurognosis to both come to know the self and the world, and to experience the transcendental nature of reality in ways that surpass the normal limitations of either the senses or rational thought" (Laughlin 1996b). Any future alterations to the brain should take into account both its transcendental nature, and its embeddedness in the world.

Possibly, the future brain may come to perceive the hidden mysteries of ecology, and therefore, learn to co-exist in the world more ecologically. A poignant question here is how will global warming and climate change impact the brain's evolution? Futurists have remained silent on this question. Will enhanced brains allow us to find solutions to global problems which have hitherto eluded us? In Carl Sagan's words, the human species is at the threshold of finding its intimate connection with the cosmos, a connection in which the brain, like a philosopher's stone, reveals the unity of life.

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