Future Communications: Mobile Communications, Cybernetics, Neuro-Informatics and Beyond

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Abstract

In the first article of this two part contribution, *The evolution of human communication,* I showed how past forms of communication have emerged periodically to help humans cope with increasing cultural complexification. In the second article, *Future Communications* I extrapolate from present-day emerging and converging forms of electronic communication to predict how different forms of human communication are set to change in the immediate future, the intermediate and in the more distant future. Two *theses* inform the conclusions that I present in the two interrelated articles:

1. The emergence of electronic forms of communication must be analysed and understood in relation to the past emergence of other forms of human communication;
2. The rapid pace at which forms of electronic communication are presently emerging, maturing and converging is determined by psychodynamic and sociodynamic forces that are as old as humankind itself.

The four major conclusions that I come to when the two interrelated articles, *The Evolution of Human Communication from Nonverbal Communication to Electronic Communications* and *Future Communications: Mobile Communications, Cybernetics, Neuro-Informatics and Beyond* are read together, are:

1. The psyches and metabolisms of modern humans were forged over aeons of hunter-gatherer nomadic existence. Our ancient nomadic souls are incongruent with present-day sedentary existence. However, it is the same hunter-gatherer nomadic soul that has embraced the conceptual metaphor cluster, *to communicate electronically is to move about, explore, travel and visit people at new destinations*, revealing a nomadic belief system as old as humankind

itself that also underpins all of our Internet-related and mobile communications.

2. In the short and medium terms, electronic communication instruments are disappearing from our desktops into the walls of our buildings and into our furniture, into vehicles of transport and clothing. In the more distant future electronic communication will diversify and disappear into our nomadic bodies electric.
3. Human bionics[1] will emerge as one of the major applications of informatics in the 21st century, first in the form of biomedical informatics, but later on in the form of biosensory enhancement for pleasure in the virtual reality leisure time industry which is beginning to emerge at present.
4. In the longer term, human communication will be extended to encompass credible communication with sentient, self-aware forms of artificial intelligence (AI) of which some forms will be identifiable as android companion robots, while other forms of AI will be diffused throughout the complex layers of informatics that will regulate the global knowledge culture that has begun taking shape since the nineteen sixties.

Information Age Communications

In 1969, the year that the first human set foot on the moon, I was asked to address fellow students at a convention that had as theme the impact that technology was expected to have on the future of humankind. After I consulted the works of a number of futurologists, I spoke on the likelihood that the rampant use of technology would cause catastrophic worldwide pollution. I also spoke about future scenarios for space exploration, and about the tremendous impact that astronomy was expected to have on humankind's understanding of our place in the universe. I concluded my speech by talking about the role that future satellite communication was expected to play in the development of global mass communications. The one topic that I did not talk about, because not even the experts had foreseen its emergence a decade later, was the personal computer, and the tremendous role that it would play in the globalisation of human culture, knowledge dissemi-

[1] Bionics: the twofold study of biological functions and mechanics, and the application of knowledge from these fields to machine design in order to create electronic devices to enhance or replace damaged limbs and organs.

nation and independent learning, once linked to a global information network that was to become known as the Internet.

The reason why I totally failed to anticipate the rise of global electronic communication, which was set to redefine how humans would live, work, learn and play in the 21st Century, is because I failed to understand that the human psyche was forged over a period of a hundred thousand years when our ancestors wandered across the globe on foot, following their major food resources, game, and foraging as they went along. The soul of present-day humanity essentially remains the same as the nomadic soul of our hunter-gatherer ancestors. The powerful grip of nomadism on the modern mind can be seen in the fact that learning is conceptualised by means of a cluster of movement metaphors. For instance, one *explores* alternatives, one *comes* to conclusions, one *goes* to look for solutions, one *arrives* at new conclusions, etc. My contention is that humans were driven to develop a facility like the Internet because it gives expression to our beliefs that learning is a journey of exploration. The Internet enables us to believe that we are surfing and going places, while in fact we remain stationary.

When I first used the fledgling South African branch of the Internet in the late nineteen eighties, I had to place a long distance telephone call from Durban to the CSIR in Pretoria. Once connected to a search agency in the USA via satellite, I furtively delivered a pre-prepared search query. Twelve hours later, I had to dial in again to the CSIR in Pretoria to download the plain text results of my query. Today we have access to a vast array of services from all over the world at local telephone call rates. For those who can afford the vastly over-priced rates charged for DSL connectivity provided by Telkom, or the marginally better priced rates charged by the satellite signal distribution company, Sentech, year-round twenty-four-hour, wide band connectivity has now become available in certain metropolitan centres in South Africa. The sad fact is that telecommunications is about twenty times too expensive in South Africa in comparison with enriched so-

cieties like the USA, Britain, Europe, Canada, Australia, Singapore and Japan.

By using one of dozens of search engines or clustering/ meta search engines (which simultaneously query multiple search engines), one can have at your disposal in seconds documents in full colour with sound and video files embedded, available day and night on more than five million servers worldwide. Worth noting is Google's Scholar search engine at www.scholar.google.com, which filters out about 95% of the irrelevant websites, allowing proper scholarly search queries. Other Google services that provide superior search facilities are Google Suggest and Google Earth.

The 20th century saw the rise of informatics as free-market, open societies increasingly began depending on the Internet to form part of an integrated global knowledge-driven free market economy, regulated by the flow of data between economies, including the flow of electronic capital that is not substantiated by bullion or hard currency. Globally disseminated knowledge flows enable national economies and cultures to rapidly adjust to trends of increasingly rapid change in order to maintain a competitive edge over economies that remain trapped in pastoral and industrial cultures.

By the most recent estimate, there are now 6.5 billion humans on the planet. We have settled every landmass on the planet with the exception of Antarctica. Equipped with the proper communication devices, any two humans who wish can now instantly communicate with one another regardless of where they are. This is a remarkable achievement, considering that until very recently we could only communicate with people in our immediate vicinity.

Present-Day Internet Communications

According to The new media Consortium (2005) a profound shift is taking place in the way people communicate and express themselves. Fueled by media that increasingly are crafted for a global audience, pervasive access to goods and services from ever more distant locales, access to networks and communication services that span

the planet, and generational ties between youth that transcend borders, a new concept of language — and what it means to be literate — is evolving.

Unlike the traditional notions of language and literacy, which are primarily unimodal and textual, this new form of communication and self-expression occurs multimodally, incorporating visual and aural elements with textual elements, and an immediacy which itself is a dimension of the new language. Technology, which has done much to make the creation and dissemination of written communication a familiar everyday occurrence for most people, plays an especially important role in these new forms as well.

Today, robust electronic communication networks integrate facilities for e-Communication, e-Commerce, e-Entertainment, e-Government, e-Health and e-Learning in information age cultures. These online facilities enable individuals to communicate with relatives on far-flung corners of the globe. They allow people to pay monthly accounts via online banking facilities, to buy and sell products worldwide, to play computer games against opponents at distant locations, to join virtual communities online, consisting of people with mutual interests, to watch downloaded movies, to access data on government department websites, or to obtain certificates and degrees by means of online self-paced learning. Ordinary people can do any or all of these at the time of their choice from any networked location in the world, including from wireless broadband networks that allow mobile communication from busses and trains.

Digital Content Delivery by means of Flexible IT Pull-Technology

Digital satellite TV, such as Skye TV in Britain and DStv in Sub-Saharan Africa has widened the range of channels and programme types to which subscribers have access. DStv, for instance, gives subscribers access to a variety of entertainment and educational channels, over and above local public service broadcaster channels like TV 1-3 and e.

Where an information technology is used that allows the content provider to control the time of delivery, one has an instance of push technology. Where an information technology is used that enables the subscriber to decide on the time of delivery, one has an instance of pull technology. A common characteristic of present digital TV channels is that they still use push technology that the viewer still has to wait for the time slot in which a program is transmitted before they can view it. In the case of international channels that transmit content in several cycles over a 24 hours period, viewers have the limited flexibility of deciding in which phase of the repeat cycle they want to view a particular programme. However, in the case of pre-recorded (non-live) digital content it is already possible in principle to implement pull technology to enable subscribers to customise at what times of which days they want to download and watch particular programmes. With the increasing sophistication of digital content compression and delivery, and particularly as competition between digital content providers increases, it is only a matter of time before content will be delivered at the convenience of individual subscribers rather than at the convenience of service providers.

Already Among Us: Small, Smart and Powerful Mobile Communication Devices

With the introduction of sound and the graphical user interface (GUI) the desktop computer in the mid nineteen eighties allowed users to take the first steps to use electronic communication in the same way as nonverbal and verbal communication. Not only could text be formatted in any way that the user desired, s/he could embed full colour graphics and sound in documents. An emerging array of multifunctional communication devices allows people to employ humankind's primary form of communication, nonverbal and verbal communication in direct person to person communication.

However, these are only the first baby steps in the mobile communication revolution that is about to unfold. The future of interpersonal communications increasingly will be powerful, mobile, multi

sensory and miniature. The past fifteen years has seen the emergence and convergence of a range of personal mobile communication instruments. It began with brick-sized voice-only mobile phones, soon followed by dual-purpose pocket size mobile phones that enabled voice and text messages. The present generation of low-end mobile phones are positively petite, with voice, text and photograph-and-send capabilities. Middle level phones are equipped with cameras, video, global positioning and Internet connectivity.

According to Hand (2004) and Hall & Dumas (2004) a range of high-end multipurpose mobile communication and computation instruments are available that allow their owners to phone, surf the Internet, and send e-mail and other documents, to word-process document and create spreadsheets that can be wirelessly downloaded on personal computers. An example of this is the multipurpose BlackBerry mobile communicator with full phone and e-mail capabilities:

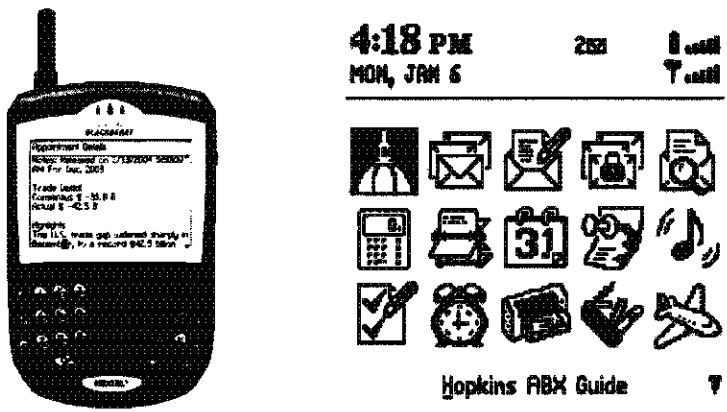

Figure 1: The BlackBerry multipurpose communicator at www.syncpak.com/ and it's on-screen program options

Mobile communications devices like the Pocket PC and other types of Smart Phones can be used for basic word processing (by using a stylus on an on-screen keyboard), e-mail, web browsing, as a

MP 3 music player, a photo album, as well as an e-library for books stored on stamp-size interchangeable 2 GB smartcards.

Such devices also allow the user or the receiver to identify the user's geographical location by means of global positioning satellite (GPS) technology, or to be navigated by voice prompts through the streets of the major cities in the USA. In addition, in the USA such mobile communications instruments are used by paramedics to upload the diagnostic vital signs of patients being transported to emergency medical facilities, and transmit them to the destination hospital so that emergency medical personnel can prepare for the treatment of the patient ahead of arrival.

Figure 2: The HP iPAQ Pocket PC using the Windows mobile operating system, graphic from *Pocket PC* October 2005, p. 7

According to Fairley (2004), a new generation of cheap, flexible solar cells could avert the world's impending energy crisis. The new solar cell technology, developed by Konarka Technologies, consists of nano-chemical surfaces printed onto flexible plastic sheets, indistinguishable from photographic film, that can be manufactured in any desired length and width, and that will deliver endless energy when exposed to sunlight. Such solar film cells will play a major role in delivering affordable energy to private homes, public institutions and mobile communication devices. They will also be utilised in smart books, lightweight bendable e-Reader tablets that can be uploaded with any amount of audio, video, graphics and text, depending on the memory capacity of the e-Reader. Electronic smart books, newspa-

pers, magazines and journals are set to replace their paper-based counterparts. New editions of these "print" media will be downloaded directly from publishers to the e-Readers of subscribers by means of wireless wideband networks.

According to Tambini (2002), we have recently seen the appearance of the virtual consultant in wireless networked communities. In situations where virtual consultancy operates, a guide with a lightweight mobile television camera mounted on the shoulders and the side of the head, enters a scene that warrants inspection and analysis. At the other end, an expert analyses the situation and decides what has to be done to solve the particular crisis at hand.

A recent addition to the range of mobile communication devices is a lightweight, pocket size personal digital assistant (PDA) with an optional extendable screen that offers telephony, global positioning satellite (GPS) tracking, access to the Internet and a virtual keyboard that uses hand movement scanning sensors to calculate which symbols on the virtual keyboard the user is pressing. The October/ November 2004 issue of the e-magazine *Pocket PC* advertises the WorldNavigator GPS travel companion that offers worldwide maps for road and marine travel, and aviation.

Already available in Japan is a range of multipurpose G3 full video communication devices that await the improvement of wireless bandwidth in the West to deliver high quality video telephony. These devices are bound to signal the demise of teleconferencing just as the present use of cell phone SMS messaging has all but stopped the use of telegrams.

Rapid developments in flexible mobile communications have led the June 7-14 2004 issue of Newsweek to give the following humorous portrayal of "your next computer":

Figure 3: *Newsweek* of June 7-14 2004's humorous depiction of immanent powerful multipurpose mobile communications

On the Horizon: Powerful Wearable Computers

Next generation communication devices will not conglomerate around the heads of people as Newsweek humorously portrays above. Instead, they will disappear into the wall of our homes, into our furniture, and for those on the move, into our clothes. The prototypes of these new mobile communications technologies are known as wearable computers (Mann & Niedzviecki (2002)). They are a range of mobile, multipurpose devices with powerful computing and communication capabilities.

Östling (2004) reports an advanced stage of development of the prototype of an exoskeletal wearable robot that could give soldiers and rescue workers exceptional endurance and strength. When marketed, the exoskeleton will consist of a super-strong metal frame into which the wearer steps. A range of body sensors coordinates the joint movements of the wearer with the movements of the robot, computed by an on-board computer in the wearer's backpack and powered by a

power source also housed in the backpack. The robot will enable its wearer to hike vast distances and to effortlessly lift heavy objects.

Vorenberg (2003) predicts that smart clothes will be on shop shelves soon. They will be items of clothing woven from smart thread, a polymer that feels like nylon fabric, but that conducts electricity like metal, and that can therefore replace traditional threads in fabric to give clothes computer-like qualities. The inventors of smart thread are exploring the possibility of using this material to manufacture wearable computing devices, wearable telecommunications devices, wearable medical and athletic devices, and wearable fashion accessories that change colour, either automatically, or on demand.

Clothing made with this material would be able to sense conditions around or inside the wearer. A smart thread shirt or blouse would have the capacity to monitor ambient temperature and to adjust and automatically regulate body heat to make its wearer more comfortable, or it would be able to diagnostically monitor the vital signs of an athlete, a child or a patient.

Telecommunications is seen as a major application of smart thread by 2010. All the components of a videophone will be woven into the fabric of the item of clothing. The fashion industry is looking at using Smart Thread to make clothes that constantly change colour, change colour based on the wearer's preference for the day, or that reflect her mood.

Within the next decade, we can expect to wear trendy clothes with more powerful computational abilities than our present desktop computers. Such clothes will allow instant audio and video communication with anyone anywhere at any time. They will adjust to regulate one's body temperature, and monitor vital signs like one's heart rate, (one's) blood pressure, (one's) blood sugar, or whatever else one wishes to have monitored. Smart clothes will alert you to take whatever medication is due to be taken at the time, and that will tell your physician more accurately what your symptoms are than you yourself will be able to do.

Also on the Horizon: Cyborgs

The eventual convergence of a number of presently emerging technologies will enable humans to engage in cyberkinetic telecommunication and communication between humans and companion robots. The technologies to which I am referring are: nanotechnology, quantum computing neuro-informatics, and cybernetics.

Nanotechnology is a new and fast expanding form of technology that is used to build complex microscopic machinery on the molecular and atomic level. Fully functional, complex nano machines are so small that about a thousand of them next to one another can comfortably pass through the eye of a needle. Nanotechnology is already being employed in computing and is set to transform computing beyond recognition in the near future (Stix (1994, 2001), Collins & Avouris (2000), Lieber (2001), Whitesides & Love (2001), Whitesides (2001), Alivisatos (2001), Roukes (2001) and Drexler (2001)).

Quantum Computing is an emerging new branch of informatics that utilises the principles of quantum mechanics that were formulated nearly a hundred years ago, and which forms the basis for modern physics, chemistry, mathematics and cosmology. Quantum mechanics is a theory that describes the behaviour and interactions of subatomic elementary particles and their energy states. According to quantum theory, energy radiates in discrete packets, known as quanta. Experiments based on quantum theory have demonstrated that matter simultaneously has two modes of existence—it simultaneously manifests itself as particles and as waves. This means that everything in the universe, including humans, is built up from particles that are located in space-time, but which at the same time exists as waves that are not subject to space-time constraints. Quantum theory further states that a particle can be entangled in space-time at two different locations, which means that it simultaneously exists in more than one place.

Because of this dual state of existence quantum theory includes an uncertainty principle, which states that an observer can either measure the velocity of a moving particle or ascertain its whereabouts, but one

cannot do both at the same time. According to the theory, quanta change their behaviour when observed, because observation involves properties of quanta that localise them in space-time.

Quantum computing uses the properties of quanta to do powerful information processing at high speeds on increasingly smaller instruments. Present-day information processing is limited to binary data states because it uses only combinations of O (zero) and I (one) to encode data strings. Because of the wave properties of quanta, and entanglement, they can manifest themselves in two places at the same time. This enables the encoding of data in five quantum probabilistic data states which makes it possible to encode vast amounts of information extremely fast by means of very small processors. Quantum encoding allows for data processing speeds that are hundreds of times faster than binary processing. Experimental quantum encryption has succeeded to use entanglement to teleport messages between communication instruments at different locations. It is already possible to teleport quantum messages. Someday it should also be possible to teleport the messenger itself. Brooks (2004:33) says:

> *... Experiments show that the size of an object is no barrier to quantum-like behaviour ... So, could you be turned quantum? It all comes down to information or the flow of it. This determines how you interact with the world, and whether you can, for example, be in two places at once. If you want to be quantum you have to isolate yourself from your surroundings by making sure there is no way that you leak information.*

Returning from what may someday become possible to what is likely in the near future, a combination of nanotechnology, quantum computing and cybernetics will within the second or third decade of the 21st century cause communication and computation instruments to entirely disappear into the human body, and will eventually become as commonplace as cell phone communication is today.

Neuro-Informatics is an emerging field of informatics in which microscopic brain implants are performed that allow nano-computers to enhance sensory inputs that enable the blind to see, the deaf to hear and the paralyzed to move.

Cybernetics is a branch of informatics that studies communication in organisms, organic processes, and in electronic systems. A new branch of cybernetics, nano-neuro-cybernetics, is studying how biological control systems in the human body could use nanotechnology at the cellular level to achieve direct human-machine communication. A new form of mathematics is being developed to translate communication between biological cells and nano-instruments in the form of body implants. The following are important facts regarding nano-neuro-cybernetics that form the basis of the discussion of cyberkinetics and neuromorphic microchips in the next section:

- Each cell in a person's body is a battery that generates its own electric field;
- Each body generates its own complex electric aural field by combining the fields of individual cells;
- The active cells during particular brain processes generate brain waves that form an intimate part of cognitive processes by helping activated groups of neurons to co-opt inactivated ones during the process of entrainment;
- By means of nano-neuro-cybernetic events neural signals are decoded and translated into electronic signals that enable people to regain abilities that have become dysfunctional and to will electronic devices through mind control to perform specific operations. The process of mentally controlling electronic devices to perform specific operations is known as cyberkinetics.
- Biological forms that are cybernetically enhanced are *cyborgs* and the process of enhancing their abilities, or of compensating for dysfunctional natural abilities, is called *cyberkinetics*.

During ***cyberkinetics*** neurological implants are used to meld neural signal processing and some form of information communication technology. This enables recipients to bypass damaged areas of their central nervous system to restore hearing and sight, or to bypass the motor cortex by tapping straight into neurons in the parietal lobe of the brain in order to directly control bionic limbs through thought processes. Advances in cyberkinetics are set to help patients with spinal cord injuries, strokes, Lou Gehrig's disease or other neural ailments to communicate better, or even to operate lights and other devices through mind control (Pollack (2004) and Warner (2004)).

A recent beneficiary of cybernetic telecommunication is the American quadriplegic, Matthew Nagle of Stoughton, Massachusetts, who can switch on and off appliances via an electrode array directly implanted into his parietal lobe, the brain lobe that integrates neural signals from different sensory pathways before sending them for executive action to the motor cortex. In Matthew Nagle's case spinal neck injury has left all four of his limbs paralysed. By decoding neural signals in the parietal lobe and redirecting them directly to a computer via a wireless brain implant it is possible for Matthew Nagle to cyberkinetically will certain actions that are then executed by his computer, or to will a bionic hand to open and close, or to grasp (Mishra (2004), Philipkoski (2005), and Unauthored News Report (2005)).

Boahen (2005:57-63) reports advanced research in the design and application of ***neuromorphic microchips***. According to Boahen neuromorphic electronics uses compact, efficient microchips that electronically emulate the brain's neuro-chemical signalling processes. A major application would be implantable silicon retinas to restore vision to human patients, and that could also form part of robotic eyes. Neuromorphic microchips also have applications in other electronic sensory systems such as audio and olfactory recognition for robots and other intelligent machines. Boahen (2005:63) concludes:

Morphing neural development processes instead of simply morphing neural circuitry holds great promise for handling complexity in the nanoelectronic systems of the future.

In summary, cyberkinetic nano-computers as wide as the breadth of a hair, are being designed that will be used for manipulating the spin orientation of electrons, utilizing probabilistic quantum spin states for data processing. Such quantum data processing will enable minute computers to process data hundreds of times faster than the binary processing of the processors that we are currently using in state-of-the-art computers.

Just over the Horizon: Companion Robots

Non-humanoid robots have been used for a number of decades in assembly settings to due repetitive precision tasks that tax human concentration beyond its limits. They basically are just expensive precision computational instruments that perform tasks in sequences that human designers have predetermined and pre-programmed. There are also a number of entertainment robots, like Honda's Asimo, that are mainly being used for promotional purposes. Asimo has no sensations about its environment and walks and talks by remote control.

In order for a robot to be intelligent, it must be aware of its environment. This cannot be done by serial information processing, the principle on which 99% of present computers on planet earth work. What is needed is a system of parallel distributed processing (PDP), also known as neural network processing, that allows the computer to become aware of its environment and to program itself by learning from its environment, just as humans do. In PDP computers, there is no distinction between hardware and software. As the computer learns about its environment, it adjusts its neural network settings, just as the human brain does. In both PDP computers and humans the continuous reconfiguration of synaptic settings, reprograms the neural network with up to date information about its environment. The present genera-

tion of PDP computers is said to have a level of intelligence comparable with insects.

Some robotics engineers are making optimistic predictions that bipedal humanoid companion robots, in the form of servants, assistants and companions could be available within the next 20 years.

At the lower end of robotic sophistication one would have a bipedal anthropoid worker like Asimo that can be pre-programmed with scripts for butler like social interactions, or with housemaid like scripts to do the laundry and wash up, and that can engage in general conversations about every-day matters. At the upper end we would be talking about self-aware, sentient beings where parallel distributive processing AI, using nano scale neuromorphic microchip technology, described by Boahen (2005), would generate an open ended, extendable knowledge base that would enable the robot to learn from, and adjust to new experiences.

Cognition, Ethics and AI

A discussion of this nature would be incomplete without an inquiry about ethical and moral issues that at this stage may be considered to be at the periphery of informatics by some information scientists. I personally believe that all species extract particular narrow sensations of the environment in the form of extremely complex species-specific mental models (memories and reasoning processes) that optimise their chances of survival in the particular niches that they occupy in nature. Different species have configurations of sensory abilities that are specialised for their own survival because the mental model of each species would constitute a partial drastically oversimplified abstraction of ultimate reality.

Memories of our past experiences give us self-identity. If my assessment is correct, we will be able to create intelligent companion robots that are sentient, not only at the limited ranges that inform human cognition, but at ranges where we are unaware and agnostic, e.g. at the X-ray range, the ultraviolet range, the infrared range and the extra low

frequency range. Using the principles of kirlian vision (revealing the auras that all life forms radiate in electromagnetic fields), caregiver robots would for instance be able to sense and diagnose maladies for which we now use separate diagnostic instruments.

It is well-known that loneliness drives people to accept radio and TV as surrogate human companions. There is no reason why humans will not also accept companion robots. It would be relatively easy to program a robot to engage in polite small talk and to signal polite submissiveness. However, to be socially acceptable and to engage in credible nuanced meaningful communications robots would have to limit their conversations with humans to sensations with which humans are familiar. They would have to be good at reading nonverbal communication cues (facial expression, gestures, tone of voice, body movement and body stance), and would have to project human emotions by means of their own body language, besides having an extensive, nuanced language based communication capability.

Particular emotions govern all forms of human behaviour. How will we enable robots to understand human behaviour and interpret human communication in view of the fact that learning and memory require the co-indexing of the facts of events and the emotions that we experienced during those events?

In the preceding article, *The Evolution of Human Communication from Nonverbal Communication to Electronic Communications,* I indicated that human behaviour ranges along a survival continuum: *co-operation>competition> confrontation*. Humans have to excel in all three types of behaviour in order to survive. Will we limit/inhibit robots to only cooperative forms of behaviour, *a la* Asimov's famous three laws of robotics? The *de facto* involvement of military establishments in research and funding of AI research make this a utopian objective. We can assume that robotic activities will range from the gentle caring of the vulnerable to the ruthless elimination of enemies.

As I stated before, humans are not brains in nutrient rich vats, but beings that experience as well as remember with our whole bodies, our

central nervous systems as well as our peripheral nervous systems. For instance, when you encounter someone with whom you have had a run in before, that hollow feeling on the pit of your stomach is part of the memories of the past encounter that have been re-awoken. Robots would have to experience emotions before they could understand human behaviour and interpret human communications. Humans distinguish between what is logically true and false, and between what is morally right and wrong. How will we enable our robots to make both sets of distinctions?

A surprising amount of human cognition and communication is metaphoric (Lakoff and Johnson (1980, 1999), Fauconnier and Turner (2002), Klopper (2002, 2003)). The hallmark of metaphoric thinking is that entities that are not literally similar are being equated figuratively in order to focus on unexpected similarities between them. For instance, depending on the nature of a competitive behaviour, opponents could be portrayed as chess players, tennis players, boxers, wrestlers or duellists. In the domain of sexual desire a desiring male can be portrayed as an old goat and a desirable female as tender leaves. Because metaphor formation is spontaneous and creative we are dealing with an open ended process of meaning creation. Therefore, the ultimate challenge would be to get robots to understand the almost infinite variety of figurative meanings that humans could evoke with such metaphors, let alone the emotive mind-body states that metaphors evoke in fellow communicators.

Conclusion

In my characterisation of the evolution of human communication and my predictions about he future of human communications I respectively showed that in order to discern future trends we first have look back at how human nonverbal and small-group verbal communication evolved over the past 100,000 years, during humankind's hunter-gather nomadic phase of existence, because the soul of modern humans was formed over aeons by our ancestors' struggles for survival against the elements, against predators and against other hominids.

I showed how in the course of the past 10,000 years new forms of communication periodically emerged in response to greater cultural complexification. I also showed how over the past 100 years electronic communications emerged as a present-day expression of our survival imperative. I showed how in the immediate future mobile communication and computation instruments are set to disappear into our buildings, furniture and clothes because the human soul that evolved over the past 100,000 years is the soul of a nomad. This is evidenced by the fact that humans worldwide use a range of travel metaphors (going online, surfing the web, visiting a website, entering or exiting a database, etc) that together forma generic conceptual metaphor "experiencing something new is moving somewhere."

I showed how the confluence of quantum computing, nanotechnology and cybernetics is leading to the emergence of the new science, neuro-nano-informatics that will cause electronic communication and computing devices to disappear into our bodies-electric. This will initially happen to solve medical problems like quadriplegia, deafness and blindness, but will give rise to cyborgs (neuro-technically enhanced humans) as a social phenomenon towards the last quarter of the 21st century. Round about the same time, or perhaps early in the 22nd century, an advanced form of nano-informatics is predicted to give rise to androids (humanoid robots) in the form of a variety of companion robots. The rise of cyborgs and androids as social phenomena will be motivated by the progressive ageing in affluent human populations in the northern hemisphere, and in response to the collapse of the core family during the 20th century as humankind's primary environment for nurturing and socialising children. The collapse of the core family has already set in motion the reconfiguration of social groups, real and virtual, in western societies. The availability of companion androids as caregivers to the young, the infirm and the lonely will be a natural extension of this process of social reconfiguration that has already begun.

Finally, in spite of unmanned probes to nearby planets at present, the nomadic soul of humans will lead to manned space exploration and

interplanetary settlement, complemented by android labour. In my estimation, human-android space exploration will be a defining feature of the 22nd century.

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