ICT Implants

The Invasive Future of Identity?

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Abstract. Is the human body a suitable place for a microchip? Such discussion is no longer hypothetical – in fact in reality it has not been so for some years. Restorative devices such as pacemakers and cochlear implants have become well established, yet these sophisticated devices form notably intimate links between technology and the body. More recent developments in engineering technologies have meant that the integration of silicon with biology is now reaching new levels - with devices which interact directly with the brain. As medical technologies continue to advance, their potential benefits for human enhancement will become increasingly attractive, and so we need to seriously consider where this may take us. In this paper, an attempt is made to demonstrate that, in the medical context, the foundations of more advanced implantable enhancement technologies are already notably progressed, and that they are becoming more science fact than is widely considered. A number of wider moral, ethical and legal issues stem from enhancement applications and it is difficult to foresee the social consequences, the fundamental changes on our very conception of self and the impact on our identity of adoption long term. As a result, it is necessary to acknowledge the possibilities and is timely to have debate to address the wider implications these possibilities may bring.

1 Introduction

The ability to form direct, bi-directional links with the human brain will open up the potential for many new application areas. Scientists predict that within the next thirty years neural interfaces will be designed that will not only increase the dynamic range of senses, but will also enhance memory and enable “cyberthink” - invisible communication with others and technology [1]. But are these claims realistic, and should they be taken seriously? Here we will look at how a fundamental shift in thinking may pave the way for greater developments in this field, and review the current state-of-the-art of implantable technology, its potential as an enhancement tool, and the likelihood that people would undergo implantation.

Please use the following format when citing this chapter:

Gasson, M.N., 2008, in IFIP International Federation for Information Processing, Volume 262; The Future of Identity in the Information Society; Simone Fischer-Hübner, Penny Duquenoy, Albin Zuccato, Leonardo Martucci; (Boston: Springer), pp. 287–295.

2 Emerging technologies and the coming years

It is clear that not all future visions will be accurate, and this goes for those debated by scientists as much as anyone else. A clear case-in-point is the assertion that, by now, Artificially Intelligent machines, with intellect to match our own, will be a great cause for concern. These, to date, have evidently failed to materialize. In a shift in approach, 'Emerging Technologies' is a new way of thinking which considers the convergence of fields such as nanotechnology, biotechnology, information technology, cognitive science, robotics, and artificial intelligence. It is considered that the next wave of disruptive technologies will actually be a result of this domain fusion rather than from any one field in isolation. Already the foundations of implantable technology are being investigated and developed for medical applications, and progress is becoming less hampered by our lack of understanding of brain functionality. It is clear that this application area is one which can be greatly enhanced through this new emerging technology phenomenon.

However, we must also consider what the state-of-the-art is currently. The relatively new trend for low-tech implants has recently risen in the public consciousness, although less publicized developments of high-tech implants in the medical domain have been progressing for several decades. Indeed, a significant drive behind the development of so called Information Communicating Technology (ICT) implant devices is medical – i.e. restoring deficient human abilities.

2.1 ICT implants for Restorative application

There is a fair range of 'restorative' devices already in clinical use, although many, such as artificial joints, could not through their function alone be considered ICT devices. Others, such as the artificial pacemaker, have actually become notably sophisticated in recent years with integrated movement sensors to adjust heart rate based on estimated demand, internal logging of biological data, and RF communication with the outside world. Of greater interest is the development of technologies which are able to interact with us on a neural level. The most ubiquitous sensory neural prosthesis is by far the cochlear implant [2]. Where destruction of cochlea hair cells and the related degeneration of auditory nerve fibers has resulted in sensorineural hearing loss, the prosthesis is designed to elicit patterns of nerve activity via a linear array of electrodes implanted in the deaf patient's cochlea that mimics those of a normal ear for a range of frequencies. Current devices enable around 20 percent of those implanted to communicate without lip reading and the vast majority to communicate fluently when the sound is combined with lip reading. Its modest success is related to the ratio of stimulation channels to active sensor channels in a fully functional ear, with recent devices having up to 24 channels, while the human ear utilizes upwards of 30,000 fibers on the auditory nerve. With the limitations of the cochlear implant in mind, the artificial visual prosthesis [3] is certainly substantially more ambitious. While degenerative processes such as retinitis pigmentosa selectively affect the photodetectors of the retina, the fibers of the optic

nerve remain functional, so with direct stimulation of the nerve it has been possible for the recipient to perceive simple shapes and letters. However, the difficulties with restoring full sight are several orders of magnitude greater than those of the cochlear implant simply because the retina contains millions of photodetectors that need to be artificially replicated, and so this technology remains in development.

While both cochlear implants and retina stimulators operate by artificially manipulating the peripheral nervous system, less research has been conducted on direct electrical interaction with the human central nervous system, and in particular the brain. Work on animals [4, 5] has demonstrated how direct brain stimulation can be used to guide rats through a maze problem, essentially by reinforcement, by evoking stimuli to the cortical whisker areas to suggest the presence of an object, and stimulation of the medial forebrain bundle (thought to be responsible for both the sense of motivation and the sense of reward) when the rat moves accordingly. Early work to translate this research to humans demonstrated radical (and occasionally dubiously interpreted) changes in mood and personalities when such 'pleasure centers' were stimulated [6, 7]. This period saw some seventy patients implanted with permanent micro-stimulators to treat a variety of disorders with reportedly good success, although the indiscriminant use of the procedure and significant failure rate saw it largely condemned. This may have been in part because the disorders targeted were psychiatric rather than neurologic, and it was not until the 1980s, when French scientists discovered that the symptoms of Parkinson's disease (PD), with better understood anatomical pathology, were treatable using Deep Brain Stimulation (DBS), that research again picked up pace. However, difficulties in accurately targeting structures deep in the brain, lack of safe durable electrodes, problems of miniaturizing electronics and power supply limitations meant that such therapy was not readily available for several more years.

Recently there has been a resurgence of interest in the surgical treatment of movement disorders such as PD. This is because of the disabling side effects of long term treatment with L-dopa, a chemical precursor to dopamine which can cross the blood-brain barrier and metabolize in the brain to address insufficient dopamine levels, thought to be a primary cause of PD. Also many movement disorders, such as multiple system atrophy or dystonia, do not respond to dopaminergic treatment at all. A limited range of DBS systems have been made commercially available and are now in clinical use despite their significant cumulative costs. Deep brain electrodes are routinely implanted into the thalamus, pallidum or sub-thalamic nucleus to alleviate the symptoms of Parkinson's disease, tremors of multiple sclerosis and dystonia. In pain patients, electrodes are implanted into the sensory thalamus or periventricular / periaqueductal grey area (see e.g. Fig. 1). The depth electrodes are externalized for a week to ascertain effect prior to internalization. A control unit and battery is implanted in the chest cavity and the electrode connections internalized after this time if good symptom relief is realized, at a cost of around £12,000.

Fig. 1. A lateral X-Ray of the head of a 38-year-old showing two Deep Brain Stimulation leads implanted in the sub-cortical thalamus area.

At present DBS is used to stimulate deep brain structures continuously at high frequencies (typically 100-180Hz for movement disorders and 5-50Hz for pain). Such high frequency DBS is probably effective because it takes command of the local networks and prevents them from relapsing into the slow synchronous cycles that may cause the symptoms of the disorder. The corollary of this is that when entrained to continuous deep brain stimulation the basal ganglia neurons are probably unable to perform their normal functions. However, the success of DBS as a treatment for the symptoms of movement disorders, combined with an improved understanding of the pathophysiologic basis of neuropsychiatric disorders has now seen renewed interest in the application of DBS for these conditions [8].

The ability of electrical neural stimulation to drive behavior and modify brain function without the recipient's cognitive intervention is evident from this type of device. Further, it has been demonstrated how electrical stimulation can be used to replace the natural percept, for example the work by Romo et al. [9]. However, in all cases these devices operate in a unidirectional fashion - the ability to form direct bi-directional links with the human nervous system certainly opens up the potential for many new application areas. However, bi-directional neural implants are very much experimental. Whilst they have much potential in the areas of prosthetics, major developments have been slow in coming. Recent research in the area of DBS has shown that by recording brain activity via the implanted electrodes it is possible to detect characteristic signal changes in the target nuclei prior to the event of tremor, and so stimulation based on a prediction of what the brain will do is possible [10]. The

development of such technologies, which are able to decode the brain's function, are clearly of great value.

Fig. 2. A 2cm long RFID tag (shown right) is invasively implanted into a healthy volunteer during a research program conducted in 1998.

2.2 Application of ICT implants for Enhancement

On Monday, August 24th, 1998, a groundbreaking experiment was conducted by Prof. Warwick's group at the University of Reading in the UK (see Fig. 2). At the heart of this work were the sub-dermal implantation of a Radio Frequency IDentification (RFID) tag¹ and the augmentation of the infrastructure at the university's Department of Cybernetics with RF nodes such that the system was able to track him, via the tag, as he roamed the building. The possibilities using this technology were, even at that time, not greatly limited, however the system was restricted to simple profiling of his behavior. From this automated customization of his environment was possible, such as unlocking doors, turning on lights and brewing his coffee on arrival.

While the public response to this work was varied, from suggestions that this was the work of the devil,² to awe of the technological possibilities, acknowledgement of

¹ In brief, RFID tags wirelessly communicate data to reader devices from which typically the power is supplied wirelessly to the tag. The data, in the simplest devices, is a unique code which identifies the tag, and thus the object, if known, to which it is attached.

² Revelation 13:16-18 "He [the beast] also forced everyone, small and great, rich and poor, free and slave, to receive a mark on his right hand or on his forehead, so that no one could buy or sell unless he had the mark, which is the name of the beast or the number of his name". Such scaremongering is in keeping with the flawed logic which demonstrates that

the prophetic merit largely mirrored that of academic musings on the scientific value. Few could appreciate the idea that people may actually be open to having such devices implanted if there was some net benefit in doing so. Equally, few entertained the realization that, at that time, RFID technology was on the cusp of becoming cost effective enough to essentially become ubiquitous.

Some six years later, implantable identifying RFID tags were commercialized by 'VeriChip' and approved by the FDA in the USA for human use. It was proposed that these devices could essentially replace 'medic alert' bracelets and be used to relay medical details when linked with an online medical database. Such devices have subsequently been used to allow access to secure areas in building complexes, for example the Mexican Attorney General's office implanted 18 of its staff members in 2004 to control access to a secure data room, and nightclubs in Barcelona, Spain and The Netherlands use a similar implantable chip to allow entry to their VIP customers, and enable automated payments.

By 2007, reports of people implanting themselves with commercially available RFID tags for a variety of applications have become a familiar occurrence (see e.g. Fig. 3). The broad discussion on security and privacy issues regarding mass RFID deployment has picked up pace, and security experts are now specifically warning of the inherent risks associated with using RFID for the authentication of people³. Whilst the idea that RFID can be used to covertly track an individual 24-7 betrays a fundamental misunderstanding of the limitations of the technology, there are genuine concerns to address. The use of implanted RFID tags in this scenario is especially thwart with issues because being implanted forms a clear, permanent link with the individual and makes compromised tags hard to revoke.

Concerns for those who have decided to have an RFID tag implanted are valid, although an assumption is that such procedures will never become compulsory and so most people will remain unaffected. However, while mass deployment of RFID technologies is well documented, especially in the context of commerce, it should be noted that, through non-nefarious means, it is possible that people could become implanted with RFID unknowingly. This is mostly related to safety issues regarding passive medical devices such as hip replacements and breast implants whereby being able to determine the exact manufacturing details non-invasively could be advantageous. This is especially valuable when manufacturing faults are subsequently discovered and devices of unknown provenance have been used. Thus embedding an RFID enabled device before it is surgically utilized would enable this function, but result in the wider issues of having RFID implanted. Further, following the polemic on silicone-gel breast implants [12], a device based around RFID technology,

the common barcode contains a hidden '666', e.g. as described by Relfe in her 1982 book "The New Money System: 666".

³ RFID technology is still in its infancy and resource-constraints in both power and computational capabilities make it hard to apply well understood privacy protection techniques that normally rely heavily on cryptography (see [11] for more information). For instance a 'man-in-the-middle' attack would make it possible for an attacker to steal the identity of a person (i.e. tag identifier), while widely published techniques for RFID tag cloning make utilizing this information technically feasible.

designed to be located inside the breast, which detects rupture has been developed, and many are investigating the benefits of being able to non-invasively monitor the condition of a medical device, such as a heart valve, using this type of technology.

Fig. 3. An individual with two RFID implants: His left hand contains a 3mm by 13mm EM4102 glass RFID tag that was implanted by a cosmetic surgeon, his right hand contains a 2mm by 12mm Philips HITAG 2048S tag with crypto-security features, implanted by a GP using an animal injector kit [13].

Exact numbers of those who have received this type of low-tech implantable technology are not known, but it is clear that the figure is rising, and, with familiarity, public acceptance will surely grow. Because we largely dismissed such uses of the technology as improbable some ten years ago, a lack of timely debate on the wider implications means that we are now faced with the prospect of addressing them whilst the technology gets a foot-hold. Not least of all, this certainly leaves some open identity management questions which technologists must now address. It is not hard to imagine that dealing with technical and wider issues retrospectively will be immensely more difficult.

Having seen the applications which RFID has found despite earlier pessimism, we should consider the application of the more advanced medically orientated technologies on healthy individuals, i.e. enhancement rather than restoration, as a distinct probability. Reports of this pioneering step are rare, although in a notable echo of 1998, the University of Reading in the UK has been active in this area. On March 14th, 2002, an array of one hundred individual needle electrodes was surgically implanted into the median nerve fibers of the left arm of Prof. Warwick, a healthy volunteer [14, 15]. This study demonstrated, in a rudimentary fashion, a range

of applications, from nervous system to nervous system communication, feedback control of robotic devices and augmented sensory capabilities.

To date there are no well reported studies involving implantation in the central nervous system of healthy volunteers. There is, however, some largely anecdotal evidence of the occasional positive side effect that DBS in patients has had. In one such case, a graphic designer, who received DBS surgery for a severe Tourettes disorder, found that stimulation through one specific electrode could actually make her more creative. Indeed, when this electrode was used, her employer noted an improvement in color and layout in her graphic design work [16]. The application of this type of effect in the long term clearly cannot be discounted, and so nor can the translation of medical devices to this area.

Society in general has come to accept restorative technologies such as pacemakers and DBS systems which have become notably advanced in their function. However, it is clearly timely to have debate regarding the potential use of this technology in individuals with no medically discernable need. A number of wider moral, ethical and legal issues stem from such applications [17] and it is difficult to foresee the social consequences of adoption long term which may fundamentally change our very conception of self and sense of identity. Intervention with regard to the possible negative impacts should clearly take place at an early point such that we are not left relying on purely legal measures.

3 Conclusions

We are already seeing simple passive technologies such as RFID being implanted in humans, and these alone introduce challenging identity and identity management related questions. Issues relating to the implementation of more advanced enhancing ICT implants are immense, and in most cases tangible solutions to technical problems are still yet to be found. However, technological advancement is a part of our evolution, and the significant next step of forming direct bi-directional links with the human brain is moving inexorably closer. It is understandable to think that since the technology has not yet and may not be perfected there is no need to address the incipient legal, ethical and social issues that the development of these devices may bring. However, the basic foundations of advanced ICT implant devices are being developed for clear medical purposes, and it is reasonable to assume that few would argue against this progress for such noble, therapeutic causes. Equally, as has been demonstrated by cosmetic surgery, we cannot assume that because a procedure is highly invasive people will not undergo it. So, while we may be some way away, there is clear evidence that devices capable of significant enhancement will become reality, and most probably applied in applications beyond their original purpose. Thus, clear consideration needs to be given now to the fundamental moral, ethical, social, psychological and legal ramifications of such enhancement technologies. It is not too soon to start real debate.

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