Re-Designing Humankind

The Rise of Cyborgs, a Desirable Goal?

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Abstract The idea that human beings are imperfect is very old. But now, for the first time in history, some people, mainly scientists, have the previously unimaginable power to modify human beings. Redesigning humankind is, generally speaking, the result of a techno-scientific complex called "converging technologies", and made up of biotechnologies, information technologies, nanotechnologies and cognitive sciences. However, we are more concerned here with electronic devices directly implanted into the human body. After an overview of what might happen to humankind, we also briefly discuss as a conclusion how bright such a future might be, considering that we have two different standpoints.

In western societies – as indeed in other societies where the definition may be different from ours – there is an inherent definition of humankind which is taken for granted and which forms our common background. As it is deeply rooted in our culture, it does not need to be formulated to be an efficient guideline. In other words, designers always have – as in fact have all of us – made assumptions on what human beings are (the descriptive aspect) and what they are supposed to be (the normative aspect). These shared values are embedded in all the objects they create, even if they are not necessarily aware of it. Until a few years ago, this normative definition was a dream without any empirical results on human beings themselves, and the process of design was limited to our environment. Now, for the first time in history, some people, mainly scientists, have the previously unimaginable power to make their normative definition of humankind a reality by modifying human beings. Contrary to common ideas, biotechnologies are not the only way in which this can be achieved. In reality, the future of humankind is not only linked to biotechnologies, but to a whole raft of techno-scientific developments. Biotechnologies are just the visible part of the iceberg, one single piece in the puzzle of

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a broader, powerful, techno-scientific complex called "converging technologies", made up of biotechnologies, information technologies, nanotechnologies and cognitive sciences. Not content to use science and technology for merely therapeutic purposes, to overcome handicaps, we are also striving with these converging technologies to enhance normal abilities[1] with criteria which evolve with technical developments. As a result, the definition of what is considered as normal is continuously shifting and things currently considered as enhancements might perfectly well be considered as therapy tomorrow (Cerqui, 2002). If we keep working in this way, we have to be aware that humankind might consequently simply disappear to give birth to a new species built according to criteria that need to be clarified, as these technologies act at the collective as well as the individual level, and they "concern the future of our species more than those of individuals who are part of it" (Hottois, 1999, 8, our translation).

Even if redesigning humankind is, generally speaking, the result of converging technologies, we are more concerned here with electronic devices directly implanted into the human body. With the recent arrival of information technologies directly implanted into the body, a qualitative threshold has been crossed as these techno-scientific developments have far-reaching implications. Our main interest here is in the type of cyborgs, part human–part machine entities, that are now being practically realized in which a human brain's action is modified through implant technology. Our choice is not insignificant, as the two authors are involved in research in this field. KW was the first human being to have an implanted chip used directly to link a computer with his nervous system. DC meanwhile is an anthropologist interested in the future of humankind in the era of cyborgs. We are convinced this particular case of redesign is a very good example with which to think about the main ethical and philosophical problems, as through technological enhancement it is clear that the overall abilities of a cyborg can be upgraded from those of a stand alone human. Extra sensory input, long distance control of prosthetics from brain signals via the Internet and a telegraphic form of communication directly between two human brains have already been achieved. In the longer term it is realistically expected that this will lead to memory, mathematical, multidimensional and significant communication enhancements to basic human capabilities.

After an overview of what might happen to humankind, we also briefly discuss as a conclusion how bright such a future might be, considering that we have two different standpoints. Our backgrounds and ideas are different, and so are our degrees of optimism about the future of humankind and cyborgkind.

[1] In 2002, a five hundred pages report was published by the American National Science Foundation and the Department of Commerce with a very clear title: "Converging technologies for improving human performance" (Bainbridge and Roco, 2002).

1 Towards a New Species?

With current technological and scientific breakthroughs, artifacts are being aligned much closer to the human body and even being merged with it. The resultant "cyborgs"[2] can take on any one of a number of forms, dependant on the balance between human and technological components. The case of cyborgs, part man part technology, shows very well the main values of our society, the direction it is heading in whilst acting according to these values, and the kind of new human or non human entity we are about to build. Nowadays, the main value, though not frequently formulated, which seems to provide the background for all these techno-scientific developments, is our ability to access and deal with information. In the so-called "information society", it is assumed by most that the quicker any access is, the better. It follows that ultimately the best way to increase the speed of access is for humans to merge with technology, thereby restricting or even removing the inherent human–technology interface delays. In Cerqui and Warwick (2005) the focus was on upstream science and technology aspects, hence these are not developed further here. What we are more concerned with in this chapter is the downstream translation of the new value into empirical results: namely the new species we humans are about to create.

The goals of the information society – connecting people[3] – are about to be realized with people physically and mentally becoming part of the network. It is the view of Mazlish (1993) that humankind crossed four important revolutionary epochs during its history. The first – Copernician – defined a continuity between humanity and nature; the second – Darwinian – indicated that humans are alive in the same sense as every other living being on earth; the third – related to Freud – linked the internal continuity inside humans with the discovery of the principles of psychology. The fourth – the one in which we are currently living – defines us as part of something much broader. A kind of collective intelligence may emerge spontaneously, as soon as people are connected in a big network, the same way intelligence emerges in individuals with the connection of neurons. According to Dyens, the human condition is an old-fashioned concept and he suggests we talk about the "intelligent condition" (2000, 20). In his view, humans are about to disappear as individuals, becoming part of an "intelligence-system" where the human is just part of a larger organism, a "'plural' being, built with skin, ideas, insects, organs, machines and cultures" (2000, 158). Those who claim that humankind, as we currently know it, has reached its limits and must now cross a threshold (see for

[2] There are several definitions of cyborgs, and for some of them technology does not need to merge with us to create cyborgs. For instance, according to Clark (2003), we are already cyborgs when we use non implanted technological devices. Moreover, the first definition, given by Clynes and Kline (1960) included other kinds of modifications than those related to technological devices – biochemical changes inducted by pharmacology for instance. We use here the word in his restrictive meaning, for describing organisms that are partly machine and partly human.

[3] The World Summit on Information Society (Geneva, 2003; and Tunis, 2005) is a very good illustration of the belief that connecting people is supposed to solve every kind of problems in the world.

instance Arnould, 2001, or Soriano, 2001) might be right. According to them, a new being, modified in its flesh is about to be born. Contrary to what might be thought (Sfez, 1995), this phenomenon is not limited to biotechnologies: information technologies are also part of human modification, even though many authors dissociate biotechnologies from other kind of technologies, as if they had a different fundamental logic. For instance, Mandosio claims that post-humankind could be the result of two different kinds of technologies. The first one is related to genetics and the second one to cyborgs. In his view, cyborgs are less dangerous because they are reversible and because they not genetically transmissible (2000, 190). He argues that there is a big difference between these technologies and concludes that robotics, genetics, and nanotechnologies should not be mixed up in their analysis. He especially denounces Joy (2000) who argues that every organism created by these technologies is able to reproduce itself. In reality, Joy seems to be right: there is only one fundamental logic which aims at creating life. Therefore, the information society has not to be defined just by information technologies: it is a mixture of information technologies, biotechnologies (Castells, 1998; Escobar, 1994; Guillebaud, 2001) and emerging nanotechnologies as they share a common fascination for information defined as the code for mastering everything (see Cerqui, 2004). Defined in this way, the information society has a main goal of creating new entities, more able, than present-day humans, to deal with information. This was in fact announced several years ago when Bureau foresaw that our future would be intrinsically linked to the complexity brought about by computers (1969, 543), even if he probably did not foresee that we would merge with them.

According to Beaune (1980), the intelligence of machines is synonymous with death because it means coldness in the heart of life's warmness. On the contrary, it is for many researchers a way to increase the length of life, and even more for approaching immortality. It shifts the boundaries of life while creating inanimate entities or pushing death away as far as possible.

Biotechnologies, information technologies, nanotechnologies, and cognitive science are clearly related to immortality, in spite of apparent differences between them. Concerning biotechnologies, this is obvious as it involves the mastering of life, in its material aspects. But this kind of immortality seems to have become less attractive that the immortality of mind. Moreover, biotechnologies could become, because of their ability of transforming flesh, a tool to make the main ambitions of information technologists become real. Information will be directly integrated into humans, who will be part of a broader network of exchange, a kind of living cells of the Internet. Immortality has been defined for a long time in terms of physical life or in terms of a soul. It is nowadays increasingly defined in terms of information and mind. The idea is that our minds could be uploaded into computers (Moravec, 1988). This idea even seems not to be considered as totally incompatible with the Christian faith: Crevier (1993) argues that, considering that Christ has risen from the dead into a new body, there is no reason why we could not live in a machine. Augé stressed that life and death are paradoxically always thought to emanate from the same starting point: the body (2001, 441), but it seems more correct to say that both are increasingly thought to exist without the body.

In such a situation, social scientists and philosophers need to think more about what we *are* rather than what we *do*. Thus, it is fundamental to develop ethical reflections, taking into account this anthropological perspective which many researchers in engineering may consider to be irrelevant: remaining human is usually not a criterion used to define what should and should not be developed in laboratories. Empirical research on the subject[4] shows for instance that even if it is taken for granted that every element of the human could theoretically be mastered and technically reproduced, there may, in the eyes of some, be a doubt concerning the future of human emotions. Opinions are divergent concerning the question of what would happen to humankind without human emotions: Would it exist in an improved version, more rational and less emotional. Or: Would it be replaced by another living being, characterized by a more developed intelligence? For some, emotions are part of the ontological definition of humankind. However there is no reason for us to stay human. In this case the evolved terminology "post-humankind" can be used. For others, emotions are not necessarily a distinct part of the definition, which is centered on rationality. In this case, we could evolve toward more reason and emotions and thereby become even more human during this process.

In both cases, despite distinct differences in the description of what humankind actually is, the normative definition is the same: we will become more and more rational. In such a perspective, it is argued that as our brain possibilities are limited, we naturally need to find some way how to improve our mental abilities. To reach this goal, we have two options: "internal or external silicon extension" (Cochrane, 1997, 8).

Let us now have a look at the result such an enhancement in our rational abilities could produce, and the various way of understanding it.

2 Post-Humankind

Leroi-Gourhan claimed in 1965 that humans should get used to being weaker than an artificial brain, as their teeth are weaker than a milled process and flying abilities weaker than those of a plane. He wondered what the future of humankind could be in a situation where technical devices are more efficient than humans in everything. He was an anthropologist and paleontologist and was concerned with the future of humankind as well as with its past. He replaced the current humankind in a very broad historical perspective and made assumptions concerning what might be in the future. One of his hypotheses was that homo sapiens could disappear to become something perhaps better but in any case different (1965, 60). Such a view is confirmed by people who currently foresee the emergence of post-humanity. For instance, according to Guillaume "technology will probably eliminate the slow link that humanity is. In spite of ethical committees' resistance, human reproduction is

[4] For more details about that research material, see Cerqui (2006).

getting more and more artificial. One day humans will be improved, even in their intellectual abilities, by embodied artifacts. Of course, such a radical and irreversible anthropological mutation is very difficult to imagine nowadays" (1999, 15, our translation).

The artist Stelarc considers that natural evolution has reached its limits and in his view we are now confronted with a post-evolution necessity to modify ourselves in accordance with our new environmental parameters and "it is urgent for us to redesign humankind to make it more compatible with machines" (quoted in Fillion, 2000, V, our translation). Wiener shared such a view and argued that our environment has been so modified that as a result we must now modify ourselves to be able to keep living in it (see Edelman, 1985, 125). The cybernetics Wiener originated in the 1940s has had an enormous influence in the new design of humankind today – human and machine acting as a whole system with sensory feedback, communication and control. The important aspect is the entire system rather than the sub-components within it.

At present space travel to reach and return from distant planets, even several of those in our own solar system, needs much more time than that available in one typical human life. Therefore we need to modify our bodies to match with such needs, being aware that these new perspectives give a different definition as to what it means to be human. Indeed it could be said that there is no longer a reason for dying (Stelarc, 1992, 28).

According to Cochrane, our next step in evolution could lead us to use "appropriate silicon as the intelligence medium to augment our wetware (brain). Future evolution would then be driven from those manifestly of nature. Further Darwinian evolution could then lead to a creeping carbon-silicon mix. At some point biological systems become inherently limited as they encounter fundamental physical limitations that constrain or prevent further evolution in some direction" (1997, 7).

In such a way of thinking, both humanized machines – for example self-organized computers or robots – and machinized humans such as cyborgs could be the next step in evolution, the qualitative rupture point being linked to the important question of improved intelligence.

Moravec is convinced that technology will replace humankind (1988), and agrees with Kurzweil who names these machines our "mind children." They have in general a very optimistic vision of such a future, contrary to Joy (co-founder of Sun Microsystems), who published a paper with the clear title: "Why the future doesn't need us" (2000). He argued that Kurweil and Moravec's ideas were unrealistic, preparing a future where humankind is totally useless.[5]

Contrary to these ideas, some authors consider it totally impossible for robots and machines to replace humans – Kemp describes it as an ontological absurdity (Kemp, 1997, 256). In such a view, it is necessary to assess what machines should

[5] His reflection is inspired by Theodore Kaczynski nicknamed "The Unibomber", a scientist who retired from everyday social life and became an anti-technology terrorist (for the history of his life see Lecourt, 2003).

do more than what they could do (see Weizenbaum, 1976). Another humanist, Fukuyama rather romantically suggests that governments should provide rules for the regulation of biotechnology to ensure that humans not disappear (2002, 29).[6] In this case, there are serious questions at stake about power and control.

3 Becoming "More Human"

A radically different approach considers that developing our rationality makes us even more human. It is a plastic vision of humankind, which implies that it is possible for humanity to adapt to a totally new environment (Packard, 1978). Leroi-Gourhan argued that "species do not get old, they evolve or disappear" (1965, 266, our translation). Thus apart from wondering whether humankind would disappear, he also developed an hypothesis about our socialization abilities. Supposing that they are infinite, a plausible evolution could in his view lead humans to live in a totally artificial environment where they would be a kind of cell between other cells. He assumed we should in this case find a new qualification to add to "homo" instead of "sapiens" (1965, 267). This view is shared by many other people convinced that humans will not disappear but will rather just assume a new form. For instance, according to Scardigli, a new digital man is about to be born as "today's technology builds tomorrow's humankind" (1992, 179, our translation). It will be a different humankind from the one we currently know, but it will still remain humankind. In this view, technology can be outside the human body or integrated in its flesh without changing anything: they are part of the hominization which is still proceeding. It means that human evolution is not exclusively biological but is extended to include cultural aspects. Human beings are becoming, in this view, more human while developing new technologies whose every new development is one more step in the direction of a better humankind.

The theory continues that the human condition is a process with different stages, and is not in a static state. Its destiny is continuously to modify and redefine itself. In this view, the process of hominization is by no means finished and future paleontologists, in several millennia, might talk about homo sapiens as about a very primitive form of humankind. What would they think of a skeleton provided with a pacemaker? Would it still be homo sapiens or not?

In reality at this stage all we can do is speculate, with only one sure point: homo sapiens is an endangered species, and technology, which most feel was fundamental to its emergence, could paradoxically be the tool of its death. "The sword of life is intelligence. As we have lived by the sword with other creatures, so we will die by the sword in the hands of robots" (Warwick, 2000, 213).

[6] Fukuyama's book focuses on biotechnologies. But as it is, in our view, impossible to separate them from other technological developments, what he argues concerns all of them.

4 A Bright Future?

The authors totally agree with each other about the plausibility of the disappearance of homo sapiens. Considering how dependent our society is on the internet, it is difficult to imagine what would happen in the case that the network stopped working – either by intervention, design or failure. Almost our entire economic system would collapse and we would have to build a new one. Such a process would take much time and energy. Moreover, machines, and more generally technology, are considered as synonymous with development and progress, and they are even thought by some (Gras, 2003) to have become more important than humans. Thus, would we even be able to think of our social and economic system independently of them? This would certainly be considered a retrograde step; the option is quite unthinkable.

On the one hand, the authors agree on the statement that technology is becoming so important in our individual and collective lives that it is difficult to think about any other option – which means that they agree on what the situation currently *is*. On the other hand, the authors disagree on what *should be* done about the situation. KW thinks we have no other choice than to merge with technology if we want to have a future. In his view, surviving with the internet means merging with it. During his second experiment, after being implanted with electrodes which could receive messages from his brain and transmit them to a computer, his nerve signals were transmitted via the internet to operate a robotic hand at a distance. He considers that future humans will be a sub-species, useless in a society lead by machines. Thus, to avoid becoming useless, he began to transform himself into a cyborg (see Warwick, 2002). He is looking forward to being the first of a new Cyborg super-species.

On the contrary, DC thinks that we should study other options, and that humans should preserve themselves as a species. The process we are in is far from being a natural evolution. The idea that complexity is naturally increasing since unicellular organisms became multi-cellular organisms does not convince her. It could be thought that contrary to other species, humans are able to think and to make projects. That means that what we are building – whatever it is – is the result of our choices and not a result of the pressure of evolution. Evolution is simply used as an argument to justify our choices.

There are only a few researchers and scientists like KW, openly arguing that we have to turn into something different from humankind. Moreover there is only, at present, KW, experimenting on himself with new technologies that could lead to such a goal. But there are many researchers and scientists – working on the same kind of technologies as him or on others – who are convinced that the devices they are creating are just neutral tools. They should become aware that the difference between what they are doing and what KW is promoting is not a difference of kind but of degree. They are in reality part of the same project for our future. As briefly mentioned, KW's project to merge his brain with the Internet is just the concrete realization of what we implicitly strive for when we develop more sophisticated connections to access the net more quickly.

Amongst social scientists, there are those who think that the social sciences must be strictly descriptive. Others, like DC, clearly think that description is just part of their job, and that they have to engage themselves in defending what is important to them. On such a view, we all have a responsibility in terms of what will happen to us in the future: researchers concretely involved in building our future are clearly responsible for what they are doing. But users who accept the use of devices that are proposed to them completely share that responsibility. DC is not an exception – she is fully part of her society, with a computer on her desk and a mobile phone in her handbag – but she thinks that we cannot just let things go the way they are going without standing back from our own practices. That means trying to anticipate plausible scenarios, analyze them, wonder whether they are what we really want for our future, and, if necessary, warn about the possible consequences of our current choices.

In other words, our future must be a collective choice, a result of interaction and confrontation between the different positions. The current original collaboration between the two authors, a cyborg-in-creation, who happily faces the disappearance of humankind, and an anthropologist deeply attached to our homo sapiens condition, is a first step in the right direction to opening the debate about what our future might and should be.

5 Nietzsche

In deciding on our future it is perhaps appropriate to investigate the likely outcomes. For a moment put yourself in the position of being a member of a new breed. Either you are an intelligent machine, or a Cyborg – you can choose. A group of humans is still in existence and, whether you like it or not, there are many of them. The situation is exacerbated by the fact that these humans used to be the dominant life form on earth for quite a few years and they are not overly happy at giving up their position to the new breed, even though they were largely responsible for originating it. They are trying therefore, as hard as they can, to destroy every member of the new breed. From the perspective of these intellectually inferior beings, the humans, if they can destroy the new breed then humans will again be the dominant life form – maybe next time they will not make a hash of it.

So what will you, and other members of the new breed do? Perhaps you could be nice to the humans. Even though they are intellectually inferior, and you do not respect them, possibly you might let them make all the important decisions. But that seems extremely unlikely. Indeed why should you be nice at all to these humans? Given half a chance they will probably try to end your life. Realistically it is dangerous to give humans any power at all, as they could easily use it against the new breed.

Of course we can, at this time, only speculate as to how members of the new breed, such as yourself, would treat humans. After all, as the new breed are all far more intelligent than humans, it is difficult for humans to guess with any considerable accuracy the actions of the new breed. However, as the new breed have stemmed

from humanity there is perhaps mileage in considering humans themselves and extrapolating from known human behavior. Nietzsche (1961) said that “All creatures hitherto have created something beyond themselves”. He asked “What is the ape to man? A laughing stock or painful embarrassment? And just so shall man be to the superman: a laughing stock or painful embarrassment”. One could understand the superman as the new breed of which we have been talking.

So, at this point in time, our best guess as humans as to how the new breed would treat humans in the future, is obtained from looking at how humans have treated those, arguably less intelligent than themselves, from whom humans have evolved. How do humans treat chimpanzees and other animals? Do we treat them as brothers? Do we elect them to government, follow their orders or even treat them as equals? We certainly do not. Indeed why should we? After all they are less intelligent than humans. It would be a considerable embarrassment to have an orangutan as Prime Minister.

What humans actually do with apes and other evolutionary ancestors is shoot them, cage them, remove their living environment and glare at them from a safe distance in zoos. We generally abuse other animals to make our own lives more comfortable, using their bodies for food or to make glue. Amazingly, in the UK, until recently foxes were hunted and killed, just for fun, for sport. That is how humans treat creatures who are only slightly less intellectually capable than themselves. A very lucky few animals we keep as pets.

In fact apes, over the years, have probably not been anywhere near the same threat to humans as humans would be to the new breed – we do not tend to witness gangs of apes roaming the streets of New York City trying to eliminate a human or two. Despite this, humans have gone out in force looking for animals in order to destroy them, in many cases to extinction.

In reality therefore we can expect that the new superintelligent breed will wish to dominate. This they will attempt to achieve in both physical and mental ways. This is the sword that humans have wielded to establish and retain the position in which we find ourselves, and this will be the sword that the new breed, who have evolved from humans, will use to keep humans in their new found position as a sub-species (Warwick, 2004).

In debating the creation of a new Cyborg species the options are considerable indeed. It is likely that many humans will not fancy the idea of taking up a sub-species role. But what can they do about it? Conversely, many other humans (like KW) will find the possibility of upgrading and becoming a Cyborg extremely appealing. If we believe in the freedom of the individual to choose their own destiny, shouldn’t that be paramount? Rather, should humans now stand up for their species and protect what we have before it is too late?

References

Augé, M., 2001, Le corps glorieux, in: *L’utopie de la Santé Parfaite: Colloque de Cerisy*, L. Sfez, ed., PUF, Paris.

Arnould, J., 2001, *La Seconde Chance d’Icare: Pour une Ethique de l’Espace*, Ed. du Cerf, Paris.

Bainbridge, W., and Roco, M., eds., 2002, *Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology and Cognitive Science*, National Science Foundation, Arlington.
Beaune, J.-C., 1980, *L'automate et ses Mobiles*, Flammarion, Paris.
Bureau, J., 1969, *L'ère Logique*, Laffont, Paris.
Castells, M., 1998, *La Société en Réseaux, tome 1: L'ère de l'Information*, Fayard, Paris.
Cerqui, D., 2002, The future of humankind in the era of human and computer hybridization: an anthropological analysis, *Eth. and Infor. Technol*. **4**:101–108.
Cerqui, D., 2004, From Turing to the information society, in: *Alan Turing: Life and Legacy of a Great Thinker*, C. Teuscher, ed., Springer, Berlin, pp. 59–74.
Cerqui, D., 2006, *Humains, Machines, Cyborgs: Le Paradigme Informationnel dans l'Imaginaire Technicien* (working title), Labor et Fides (Collection Champ Ethique), Genève, to be published.
Cerqui, D., and Warwick, K., 2005, Can and why should converging technologies bridge the gap?, in: *Proceedings of the CEPE 2005 conference (Computer Ethics: Philosophical Enquiry)*, University of Twente, Netherlands.
Clark, A., 2003, *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence*, Oxford University Press, Oxford.
Clynes, M., and Kline, N., 1960, Cyborgs and space, *Astronautics* **27**(7):74–76.
Cochrane, P., 1997, *Tips for Time Travellers*, Orion, London.
Crevier, D., 1993, *A la Recherche de l'Intelligence Artificielle*, Flammarion, Paris.
Dyens, O., 2000, *Chair et Métal. Evolution de l'Homme: La Technologie Prend le Relais*, vlb, Montréal.
Edelman, B., 1985, Nature et sujet de droit, *Droits* **1**:125–142.
Escobar, A., 1994, Welcome to Cyberia: notes on the anthropology of cyberculture, *Curr. Anthr*. **35**(3):211–231.
Fillion, O., 2000, Stelarc ou le corps transformé, *Le Monde Interactif*, 20 décembre: V.
Fukuyama, F., 2002, *La Fin de l'Homme: Les Conséquences de la Révolution Biotechniqu*e, La Table Ronde, Paris.
Gras, A., 2003, *Fragilité de la Puissance. Se Libérer de l'Emprise Technologique*, Fayard, Paris.
Guillaume, M., 1999, *L'empire des Réseaux*, Descartes, Paris.
Guillebaud, J.-C., 2001, *Le Principe d'Humanité*, Seuil, Paris.
Hottois, G., 1999, *Essais de Philosophie Bioéthique et Biopolitique*, Vrin, Paris.
Kemp, P., 1997, *L'irremplaçable*, Les Editions du Cerf, Paris.
Joy, B., 2000, Why the future doesn't need us, *Wired* **8.04**.
Lecourt, D., 2003, *Humain Post Humain*, PUF, Paris.
Leroi-Gourhan, A., 1965, *Le Geste et la Parole (II). La Mémoire et les Rythmes*, Albin Michel, Paris.
Mandosio, J.-M., 2000, *Après l'Effondrement. Notes sur l'Utopie Néotechnologique*, ed., de l'Encyclopédie des Nuisances, Paris.
Mazlish, B., 1993, *The Fourth Discontinuity: The Co-Evolution of Humans and Machines*, Yale University Press, New Haven.
Moravec, H., 1988, *Mind Children: The Future of Robot and Human Intelligence*, Harvard University Press, Cambridge, MA.
Nietzsche, F., 1961, *Thus Spoke Zarathustra*, Penguin Classics, London.
Packard, V., 1978, *L'homme Remodelé*, Calmann-Lévy, Paris.
Scardigli, V., 1992, Toward digital man?, in: *The Immaterial Society: Design, Culture and Technology in the Postmodern World*, M. Diani, ed., Prenctice-Hall / Simon and Schuster, Englwood Cliffs, NJ, pp. 179–191.
Sfez, L., 1995, *La Santé Parfaite: Critique d'une Nouvelle Utopie*, Seuil, Paris.
Soriano, P., and Finkielkraut, A., 2001, *Internet, l'Inquiétante Extase*, Mille et une nuits, Paris.
Stelarc, 1992, Portrait-robot de l'homme machine, *L'Autre Journal* **27**:24–29.
Warwick, K., 2000, *QI: The Quest for Intelligence*, Piatkus, London.
Warwick, K., 2002, *I, Cyborg*, Century, London.
Warwick, K., 2004, *March of the Machines*, University of Illinois Press, Urbana-Champaign.
Weizenbaum, J., 1976, *Computer Power and Human Reason*, W.H. Freeman, San Francisco.