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Cyborgization yesterday, today and tomorrow: Selected perspectives and educational contexts

1. Introduction

Man's eternal aspiration to achieve "self-enhancement" seems so natural that it is actually difficult to draw the beginning of these enhancements. From the dawn of history, the humanity wants to reach farther, more, faster, stronger, fuller, wider … Without doubt, both previously and nowadays there have been people among us who do not care about expanding their possibilities (in whichever way), whom the constant everyday of tomorrow allows for an "even" existence. It is not, however, a proof that the man does not want to "reach farther than the sight". It is obvious that mechanical eras made it possible to (in a way) expand our bodies in space, and the electrotechnics allows us to expand our nervous system to the entire globe (Logan, 2010), and actually far beyond its borders. We have become (and are still becoming) conscious inhabitants of the global village, and at the same time we have started to be citizens of a shrinking world, though it is a world of wider and wider horizons. Many technical solutions, devices that accompany the man, and mass media have become fragments of ourselves expanded and scattered into public domain. Their influence on us usually consists in activating new senses in new configurations. The way of acting, using and receiving further devices undergoes constant transformations, which in turn influences the enhancement of our own possibilities (Przybyła, 2012). In this context, McLuhan's "the wheel is an extension of the foot" is not the beginning of the human aspirations to enter a higher level; it is just a palpable proof that humanity aimed at expanding its possibilities much earlier than 4,000 years BC. Irrespective of whether we view it as a potter's tool or the beginning of a revolution related to travelling, the invention of the wheel is just a result of human aspirations, and not their clue. It is through tools that humanity has tried to carry out those activities that were impossible to carry out with "bare hands"; alternatively, those tools made it possible for us to carry out work on our own, which would not be possible but for these tools. Both in the stone age, and in the following bronze and iron eras, *homo sapiens* focused on making the reality easier for themselves, using the tools that they themselves created. The beginning of this intentional process (known to us from archaeological research) stems back 2.6 million years. Initially, these were primitive but functional tools made of animal bones and corns, stone and wood; and gradually (along with discovering metal ores) they were replaced with copper and zinc alloys that were used to cast axes, hammers, chisels, as well as ornaments and weapons. The next step was to replace soft metal alloys with iron alloys. From the very beginning, the man incessantly aspired to being more efficient, and it applies to all the spheres of our lives.

The notion of cyborgization is above all a process of intentional, thus conscious, enhancement and development of human cognitive functions with the use of technical means available. It means deliberate influence on the course of a series of human life processes, also including our development and education. Cyborgization is therefore an eternal human drive at upgrading oneself to higher levels of development (which probably should be called "moving up to higher levels", using the terminology from computer games). It is thus a process that is naturally instilled in the will to speed evolution up, as evolution seems to be a process that is too slow for the modern man.

The cyborgization of man also appears to be specific prosthodontics from the angle of subassemblies for the man. Currently, many human organs or entire body fragments are replaced or enhanced with the use of technical means. Starting from the human brain, that is the headquarters for the whole organism, being nowadays implanted with electrodes (e.g. in the motor cortex) or microchips that eliminate the effects of epilepsy in Parkinson's disease, and maybe also Alzheimer's (Mussa-Ivaldi, Casadio & Ranganathan, 2013). We are also implanted with artificial eyes, ears and larynxes. Enhancing the man also entails artificial internal organs, such as: the heart, kidneys, bladder, intestines and blood vessels. These are also artificial bones, joints, muscles, skin and spine fragments. It also means filling bone cavities, including the human skull. Without doubt, the future of medicine is to link the artificial with the natural, interpenetrate and supplement ourselves with subassemblies for the man; it is the development of bionics, nanotechnology; these are microchips; it is the convergence of many different "devices".

However, going back to historical threads, from the angle of the abovementioned prosthesis or cyborgization of man it has to be noticed that it is not a discovery from the current or previous century, nor is it a subject that developed together with new technologies and their explosion. We can use the example of the last of the "human subassemblies" mentioned, that is, the skull. Nowadays, bone cavities in the skull are replaced with rolls of synthetic fibre that are sewn directly to the bones with polymer thread. Other solutions include ceramic elements, and still metal materials, too; also titanium plates and nets are still used due to their durability and lightness, and the fact that they do not hinder diagnosing a patient, being inexpensive at the same time. "Another material that is often used in the plastic surgery of the skull are plastic masses (Cranioplas) that make it possible to manually form the shape of the implant (…) after forming the lobe by milling with a high-revolution drill. Very often, the synthetic material that is used are plates made of compressed fibre (Codubix) whose surface is preformed and whose shape is adjusted by cutting the plate accordingly. One of the most modern materials is hydroxylapatite in the form of paste that makes it possible to 3D-form the shape of an implant. After implanting, the hydroxylapatite is gradually replaced with the patient's own bone undergoing bioresorption" (Głowacki, 2007). The solutions mentioned, slightly bloodcurdling, prove that modern medicine reinforces and supports humanity by supplementing the cavities created in tissues as a result of injuries and disease. Every day, teams of experts study more and more possibilities of supplementing, replacing and supporting human organs, or even entire limbs, with state-of-the-art implants (Mussa-Ivaldi, Casadio & Ranganathan, 2013). Nowadays doctors and surgeons are very often supported with extremely precise hands of robots, as their mission now is not only a successful surgery, but also a quick or even immediate recovery and full fitness, related to minimal damage to health. The Da Vinci surgical system is a good example – it is a system of a medical robot whose precision goes beyond that of the human eyes and hands; what is more, these arms (Yakoubi, Hillyer & Haber 2012), three or four of them depending on the version, do not go numb, shake or get tired, and importantly, are (still) totally dependent on the will of their operator. In this context we can talk of an incredible revolution that has started in medicine by means of new technological solutions. Making reference to McLuhan's "wheel" once again, we can definitely claim that the arm of a robot is an extension of the arm of the surgeon. However, it is neither innovative nor a need of the world today. Undoubtedly, the techniques of cyborgization have changed when we consider electronic implants that send signals to the brain and back, e.g. to bionic limbs (Donoghue et al., 2007; Orenstein, 2012; Cullen & Smith, 2013). Still, it is worth noticing that 6,000 years ago ancient Egyptians carried out skull trepanation filling cavities with metal plates. Current archaeological surveys confirm that after the surgery such patients would enjoy good health for some time. Looking for more local examples among "national cyborgs", hetman Stefan Czarniecki, probably well-known among Poles, at least from the national anthem, is worth having a look at. After suffering from head injuries, that brave man was "equipped" with a metal crown. Irrespective of whether we look at our national hero or those Egyptian patients, we can definitely see that although the "cyborgizing" materials may have changed, the willingness to enhance ourselves has remained the same.

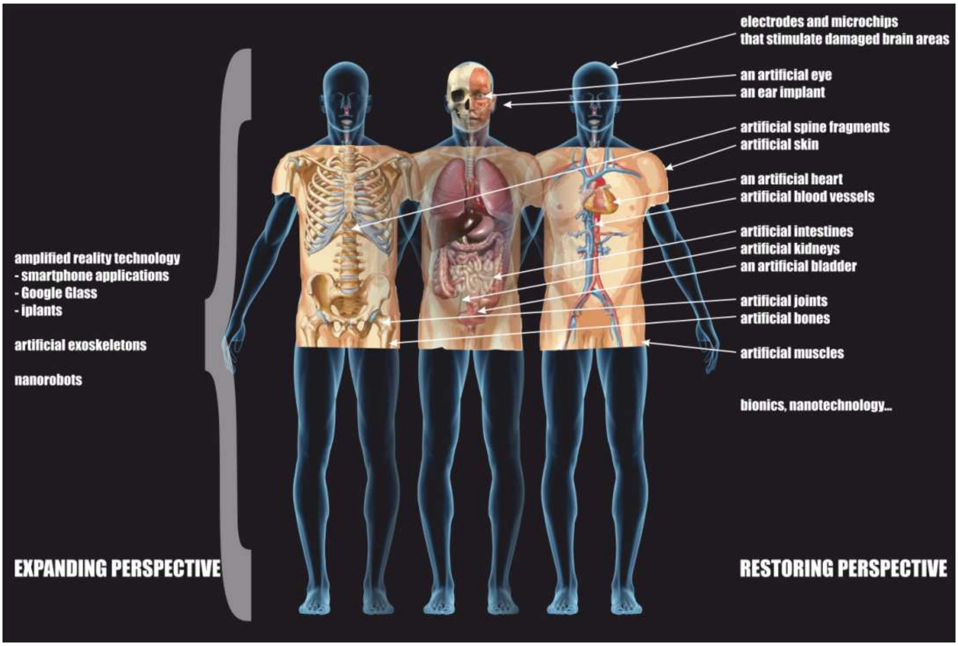
In both the historical and contemporary contexts, special attention should be paid to how men aspire to the process of cyborgization which symbolically can be named restoring and expanding. At the same time, we have to remember that – in the context of the issues already mentioned – the willingness to both restore and expand human possibilities has been accompanying us invariably for ages. As far as the expanding cyborgization is concerned, we shall present its two exemplifications in detail, dividing them into two groups: expanding by physical enhancement and expanding by cognitive enhancement. The perspective of expansion through cognitive enhancement shall also be discussed in the context of the visions of the cyborgization of the future that are currently created. It is especially important for teachers because these visions draw a picture of a dichotomous perception of the relation between education and cyborgization. This dichotomy refers to the fact that on the one hand futurologists claim cyborgization is a technology of an excellent educational potential, and on the other hand they conjecture about a world of cyborgs that exists without education.

2. Two perspectives on cyborgization

Cyborgization, understood as enhancing the man with various technical solutions (Lapum et al., 2012), can be viewed from two perspectives: restoring (therapeutic) and expanding. From the restoring perspective, technology plays the role of an amplifier of damaged functions or organs. Examples are numerous: an ear implant, an artificial heart, an artificial eye, artificial kidneys, an artificial bladder, artificial intestines, artificial blood vessels, artificial bones, artificial joints, artificial muscles, artificial spine fragments, artificial skin, or different types of prostheses and orthoses, as well as electrodes and microchips that stimulate damaged brain areas (Yokoi, 2009; Christie & Bloustien, 2010; Valente, 2011; Vlahos, 2011). The most recent research from this field deals with the so-called bionic limbs, i.e. a technology that allows to directly link prostheses (e.g. an artificial hand) to the central or peripheral nervous system (Cullen & Smith, 2013).

In the expanding perspective, cyborgization is presented as including technical solutions in the course of uninterrupted physical and cognitive processes. From this perspective, technology is thus not included in the process of reinforcing damaged functions, but in reinforcing those that function well in order to expand them (leading them to an overhuman shape, in a very lax understanding) (Saniotis, 2009; Fleischmann, 2009; Mushiaki, 2011; Palese, 2012). This is an educational perspective in a sense, because cyborgization in fact is an intentional action meant to enhance the man both physically and cognitively. Examples of such reinforcements include artificial exoskeletons (physical enhancement), amplified reality technology (smartphone applications, Google Glass, iplants) or nanorobots (cognitive enhancement), which will be discussed in two following points.

Some distinguished perspectives of cyborgization are presented in picture 1.



Picture 1. Two perspectives on cyborgization (source: own work)

3. Cyborgization as physical enhancement

The idea of physical enhancement with technology through an artificial exoskeleton is correlated with the changes in thinking about disabilities caused by Oscar Pistorius's career. Not only did this South African disabled (double leg amputee) runner win the most important athletics titles in the Paralympics, but he also competed with able-bodied runners (van Hilvoorde & Landeweerd, 2010). Many researchers claim that by using carbon-fibre prosthetics Pistorius could gain significant advantage over able-bodied runners (Callaway, 2012). Currently, Pistorius is under arrest, which makes it impossible to verify this thesis, yet his career became a popular exemplification of the transformation of a dis-abled to a super-abled. The super-ability of the person with a prosthesis also made us realise that advanced prostheses not only bring back the ability, but also widen the possibilities. This is how the concept of an artificial exoskeleton was created, i.e. a prosthetic structure that is not prosthetics, used as a physical enhancement of an able-bodied person (van Hilvoorde & Landeweerd, 2010).

Picture 2. Sample artificial exoskeletons: Hercule and Hulc

Source: fot. Remigiusz Wilk, reprinted with permission of the author

The artificial exoskeleton was initially used in case of people suffering from leg paresis, yet now it is mostly used by soldiers, and in China by policemen and many gardeners and fruit farmers. Most often, the artificial exoskeleton is made of titanium and powered by small but very efficient engines. It plays the role of a bone and muscle extension. On the one hand, it stabilizes the body and protects it from injuries, and on the other it gives more strength, makes it possible to march longer, run faster, lift and carry heavier weight, and move with more load (e.g. rucksack, rifle or a fruit box) (Vlahos, 2011). A sample artificial exoskeletons are shown in picture 2.

Designed by the Lockheed Martin company, the artificial exoskeleton named HULC makes it possible, for example, to walk, run, kneel, jump or even crawl with a rucksack weighing 90 kilos (in the future, the weight is to be increased up to 400 kilos), as well as lift objects weighing several dozen kilos (and in some contexts, even more than 100 kilos), with hardly any effort. Additionally, according to the producer's description, this equipment does not limit the movements of a soldier in any way (www.lockheedmar tin.com, 21.02.2014).

4. Cyborgization as cognitive enhancement

The idea of cognitive enhancement with technology is an outcome of developing a well-known concept of the brain-machine interface (Saniotis, 2009). This concept is related to the cybernetic dream about creating a complex machine-man system (Trąbka, 1994) or a communication bridge between the biological (analogue) and electronic (digital) worlds (Kurzweil, 2013b). Such a system or communication is to be achieved through an implant to the brain that will allow for direct communication between neurons and a computer (Saniotis, 2009). Such an implant would use the augmented reality technology; it would simultaneously and interactively expand mental representations of the physical world with images of the virtual world (Topol, 2012). Augmented reality (AR) "supplements" the real world (which does not change of course) with new images or information (virtual layer). This supplementation can be some simple information (street names, navigation data) or it can be based on complicated photorealistic objects that blend in the real world and fit with it into a whole (e.g. in case of reconstructing destroyed historic buildings, military simulations etc.). Augmented reality is not equal to virtual reality (VR), that creates a new world which is computer-generated with the 3D technology. AR does not create "virtual worlds"; it recognizes real world objects and then adds virtual information to them. The currently developed AR applications put much emphasis on the virtual "augmentation" to be "indiscernible from reality" (Dejnaka, 2012: 1-2).

Augmented reality exists between the real and virtual worlds (Ullah Khan et al., 2011); it expands the actual world with virtual elements, but it does not build a world different from the real one (Lee, 2012). AR's aim is thus not making the reality unreal, but augmenting it, supplementing the real image with a virtual image that augments the reality (Thornton, Ernst & Clark, 2012). The world of augmented reality is therefore a mixture of real and virtual reality; it is a world of mixed reality (Jaramillo et al., 2010).

Research on AR implants inserted in the brain is conducted all over the world; we do not know yet if they will ever be created. Still, augmented reality can be used even today, e.g. through Google Glass produced by Google, that add an augmented image over the image perceived by the eye (Yakob, 2012) and many smartphone applications (e.g. Layar), that augment the image registered by the camera with virtual elements (Klichowski & Przybyła, 2013). It is thus possible to use augmented reality by looping at a given object (through glasses or smartphone screen), e.g. a monument, and learn about when and who founded it, how much it cost, what material it is made of and see what the space around it looked like five or a hundred years ago (Klichowski, 2014) (picture 3).

Picture 3. Augmented reality in the Google Glass concept

Source: own work

In a sense, augmented reality is a corrected reality because it not only expands the world but also brings order to it. Kurzweil (2013b: 308) writes in this context: "We will also have a corrected reality where the real world will be covered with screens that provide hints and explanations in the real time.

For example your retina display [such as *Google Glass*] can remind you: 'This is Dr John Smith, the ABD Institute Director; last time you saw him half a year ago at a XYZ conference' or 'This is the TimeLife Building; your meeting is on the 10th floor'".

Nanotechnology, or the technology nanorobots to be more precise, is to become another strategy for cognitive (and also physical) reinforcement (Hook, 2004). Thousands, or maybe millions, of nanorobots, or robots of nanometric sizes, i.e. of the size of a single atom, are to travel in our blood circulation system in the future. "This idea is not as futuristic as it may seem. Based on it, successful experiments have been carried out on animals and there are already many microdevices in their blood vessels. At least four conferences devoted to BioMEMS (biological microelectromechanical systems) deal with devices that are placed in the human blood circulation system. Let us consider a few examples of the technology of nanorobots which, thanks to miniaturization and cost reduction, will be affordable in less than 25 years. […] There will be billiards of nanorobots running in our blood vessels. They will destroy pathogenes, correct DNA errors, eliminate toxins and carry out many other tasks to boost our physical well-being. As a result, we will be able to live an endless life, without getting old. In our brains, huge numbers of nanorobots will interact with our biological neurons. In this way, access will be secured from the centre of our nervous system to full virtual reality that embraces all senses, as well as neurological correlates of our emotions. Also, what is more important, the tight connection between our biological thinking and non-biological intelligence that we create will greatly develop human intelligence" (Kurzweil, 2013b: 246-247, 297).

Kurzweil (2013a) claims that nanorobots will lead to the creation of a completely new brain soon; a brain with no limitations, without biological marks, without any limits. It is worth adding that there is no space for education in the world of nanorobots. In this reality, it is nanorobots that provide people with knowledge and skills; they are transferred directly, without any learning process, just like new software is installed in computers nowadays. In this context, Kurzweil (2013b) talks about a port (interface) in the brain that will allow the man to download patterns of neural connections and neurotransmitters that reflect the neurostructure of the skills or knowledge desired. Conjecturing about life in the year 2100, Stephens (2012) claims that a cyborg of that time after waking up on a day when he is supposed to set off on a long journey will be able to upload 20 foreign languages directly to his brain, thus mastering these languages in a split second.

5. Conclusions: Cyborgization and education – where are we heading?

Lee (2012) noticed that when cyborgization is viewed as strengthening the man with various technological solutions, it seems to be a very promising perspective for the development of education. What is more, he specified that augmented reality can turn out to be the most effective technology for education and business that we have developed so far. On the one hand thus, the perspective of the cyborgization of tomorrow lacks space for education; on the other hand, its great educational potential is visible.

Many antagonisms of this type could be enumerated. The aim of this article though is not to present the perspectives of cyborgization or its educational contexts in detail. Our aim was only to stress the dichotomy of the educational perception of cyborgization. Once its existence is noticed, teachers may be motivated to study both the educational potential of this process and diagnose the threats that are related to it. This is the objective of the Education Cyborgization Research Group (cyborgizacja.amu.edu.pl) at the Adam Mickiewicz University in Poznan. Research carried out by this team may help explain the multifaceted relation between cyborgization and education, both from the philosophical and didactic, and empirical points of view.

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