

Human augmentation and the age of the transhuman

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Chapter Abstract: Human augmentation is discussed in three axes: the technological means, the ability being augmented, and the social systems that will be affected. The technological augmentations considered range from exocortical information and communication systems, to pharmaceuticals, tissue and genetic engineering, and prosthetic limbs and organs, to eventually nanomedical robotics, brain-computer interfaces and cognitive prostheses. These technologies are mapped onto the capabilities which we are in the process of enabling and augmenting, which include extending longevity and physical, sensory and cognitive abilities, and enabling control over emotions, moral behavior, and spiritual experience. The impacts of augmentation on the family, education, economy, politics and religion are considered individually, but their aggregate effects will be non-linear and drive complex adaptations in the living machine that is our co-evolved techno-social civilization.

Keywords: cyborg, augmentation, enhancement, transhumanism, posthuman

1. Scope of chapter.

There are three axes on which to map the social implications of human augmentation: technological, the ability which is being augmented, and the social systems that will be affected.

The technological augmentations to consider range from the exocortical information and communication systems – laptops, smartphones and wearables - that are becoming extensions of the human body and brain, to pharmaceuticals, tissue and genetic engineering, and prosthetic limbs and organs, to eventually nanomedical robotics, brain-computer interfaces and cognitive prostheses. Each technological form of augmentation can in turn be mapped onto the capabilities which we are in the process of enabling and augmenting:

- a. Eliminating physical disabilities and extending physical abilities
- b. Curing disease and extending healthy longevity
- c. Eliminating sensory disabilities and extending the senses
- d. Eliminating cognitive disabilities and enhancing memory, cognition and intelligence
- e. Curing mental illness and extending emotional control
- f. Controlling addictions and moral failings, and augmenting our capacities for moral self-control, sentiment and cognition
- g. Exploring and augmenting our capacity for spiritual experience

In each of these domains we already have assistive technologies and pharmaceuticals that straddle the therapy-enhancement divide, and are in the process of developing genetic and nanorobotic technologies that promise even more radical augmentation.

The enhancement of human capabilities in each of these domains will drive changes in social systems from the family and education, to the economy, politics and religion. These impacts can be considered individually, but their aggregate effects will be non-linear and drive complex adaptations in the living machine that is our co-evolved techno-social civilization.

2. Technological augmentations of human abilities.

- a. Eliminating physical disabilities and extending physical abilities

The most important ways that human physical abilities have been augmented have been through progress in the prevention of physical disabilities, and in the mastery of energy to power machines. Between declines in the crippling effects of infectious disease, violence and war, and the declines in injuries in agricultural and industrial work, the incidence of physical disability has declined since the nineteenth century. Improved nutrition and sanitation, reforms of workplace and auto safety, and the decline of violence have all reduced the likelihood that the global citizen will suffer from musculoskeletal impairments such as paralysis and loss of limbs. On the other hand the extension of longevity has introduced the countervailing trend of a growth in the incidence of arthritis and other aging-related physical limitations.

The domestication of draft animals, steam power, electricity and the internal combustion engine all can be seen as augmentations of human physical abilities, allowing us to carry heavy objects, move about and even fly. Looking more strictly at direct physical augmentations, however, we can see that assistive technologies also have an ancient provenance. Prosthetic arms and legs have been recorded for thousands of years for instance. But the twentieth century saw the widespread availability of wheelchairs, the most advanced models of which are now fully powered, able to climb stairs or hold the user upright, and be controlled by brain-machine interfaces (EPFL, 2013). Prosthetic limbs are now capable of direct control from peripheral nerves, and of receiving sensory feedback from the prosthetic. Exoskeletal robotics are enabling those with movement disorders to walk, while also enabling the able-bodied soldier or worker to carry heavy objects. Just as the airplane and helicopter have enabled humans to transcend human limitations, the next generations of prosthetics will possess strength and capabilities that surpass organic limbs.

Eventually all the causes of physical disability will be subject to either prevention or amelioration with pharmaceuticals, tissue engineering and nanomedicine. Research is proceeding on limb cloning and transplantation, as well as limb regeneration. Stem cell and genetic therapies are progressing to repair spinal nerve damage. Tens of thousands of people have received deep brain stimulators that ameliorate Parkinsons, epilepsy and other tremor disorders. Drugs and gene therapies are being explored to treat age-related muscle deterioration, which will then provide the next generation of performance enhancing drugs and gene tweaks. Even if aging, obesity and a decline in physical activity are having a negative effect on physical capabilities in the early 21st century, by century's end many human beings will have access to greater strength, dexterity, and endurance than humans have ever enjoyed.

b. Curing disease and extending healthy longevity

As with physical disability, the years of healthy longevity enjoyed by most human beings have improved dramatically in the last century, largely as a result of improvements in public health, workplace safety and the decline of violence. According to the Global Burden of Disease Study men and women worldwide have gained an average of ten years of life expectancy just since 1970 (Wang, et al., 2012), while healthy and disability-free years are also increasing albeit more slowly.

A variety of machine augmentations promise to transform health maintenance and the treatment of disease in the coming decades. One avenue is the development of wearable biometric monitors and implanted devices, networked with smartphones and health providers. Diabetics are having devices implanted with devices that measure blood sugar and release insulin in real-time. Heart disease patients wear heart monitors or have wifi-enabled pacemakers that can alert first responders of a cardiac event. Wearable e-health devices are measuring steps taken and calories burned, toilets can provide urinalysis, and smartphone accessories can detect and diagnose signs of disease from the breath and blood.

The next stages of healthy longevity however will have to come from re-engineering the body itself, from immune response and tissue repair to the mechanisms of aging. The SENS Research Foundation, for instance, proposes seven specific pharmaceutical and tissue-engineering therapies that could feasibly reverse seven mechanisms that cause age-related disease. Further out all tissues and body processes will

be augmented with nanorobotics with robust capabilities, identifying and eliminating pathogens, repairing tissue damage, and supplementing oxygenation.

c. c. Eliminating sensory disabilities and extending the senses

The augmentation of hearing and sight began hundreds of years ago with the development of "ear trumpets" for the hard of hearing, as well as eyeglasses, magnifying lenses, microscopes and telescopes. In this broadest sense radio astronomy, medical imaging, television, radio, and communication technologies are all sensory enhancements. As Robert Hooke first surmised when he popularized the microscope in the seventeenth century, we have now arrived at the point where we are connecting these devices directly to our nervous systems.

Fortunately the decline of infectious disease and accidental injuries has reduced the percent of the population who are blind or deaf, although as with other disabilities, the growth of the elderly population has also driven a growth of age-related loss of hearing and sight. With progress in the use of stem cells and tissue engineering to repair cochlea and retinas, all forms of sensory damage will be reparable in this century. In the meantime the blind and deaf are also the early adopters of augmentations that will not only overcome their disabilities, but eventually provide enhanced sensory prosthetics to those with ordinary sight and hearing.

More than 200,000 formerly deaf worldwide have received cochlear implants, translating microphones into electrical impulses to the cochlea, providing an increasingly fine-tuned alternative to organic hearing. Hearing devices are also being connected directly into the aural nerve and the auditory brain stem, and being integrated with cell phones and Bluetooth music players. Progress is being made with photosensitive implants in the retina, and with systems that translate images into electrical impulses directly into the visual cortex. Shrinking, mobile arrays that analyze the contents and chemistry of the air and fluids can also be thought of as machine extensions of smell and taste, although capable of detecting far more than their organic analogs. Although it will more attractive to use wearable versions than to have them surgically connected, sensory prosthetics will eventually be cheap, safe and powerful enough to be a plausible replacement for the standard issue organics.

d. Eliminating cognitive disabilities and enhancing memory, cognition and intelligence

As with health and disability, the dramatic improvement in cognitive capacities throughout the world in the last century, the "Flynn effect," is largely the result of improvements in nutrition and health, as well as smaller families and more enriched intellectual stimulation. In the last twenty years however, the rapid spread of access to computers, smartphones and the Internet has meant that the average person has access to billions of times more information and memory than their unaugmented predecessors. We are now

entering the next phase of exocortical cognitive enhancement with the development of wearable computers like Google Glass, integrating information ever more seamlessly into daily experience.

Meanwhile pharmaceutical cognitive enhancement has spread with the use of stimulant drugs and non-stimulant drugs like modafinil. Large scale genomic studies are identifying genes and neurological variations that create differences in cognitive abilities, opening new avenues of pharmaceutical and genetic cognitive enhancement. Consumers already have access to wearable EEG monitors to track their distraction and focus, as well as transcranial electric stimulators that appear to improve some cognitive abilities. By midcentury these approaches are likely to be surpassed by brain-machine interfaces enabled by hybrids of synthetic biology and nanorobotics, establishing millions of connections between the brain and external information and computing power. Instead of having to talk to our glasses or type on a virtual keyboard we will be able to record our experience, retrieve information, and communicate at the speed of thought, while directly modulating our capacities for attention and decision-making. We will rapidly be able to learn skills, and edit and share memories just as we now upload photos to Facebook.

e. Curing mental illness and extending emotional control

The original essay on the cyborg by Manfred Clynes and Nathan Kline (Clynes & Kline, 1960) was centrally concerned with providing a back-up for NASA's ground control of astronauts who might suffer mental illness in space, detecting psychoses and having their suit inject them with anti-psychotic drugs. The era of treating mental illness with marginally effective pharmaceuticals with multiple side effects, like SSRIs, will likely soon be looked back on with the horror that we now view the madhouse and the prefrontal lobotomy. The genomic and functional mapping of the brain now underway, combined with the development of gene therapies, nanomaterials, and eventually nanorobotics will enable therapies far more targeted and effective at relieving depression, anxiety and fear. Beyond the treatment of mental illness, we will increasingly have a fine-tuned control of our emotions. Just as we may now drink coffee to be more alert and cheerful for the work day, and alcohol in the evening to facilitate relaxation, we will eventually be able to turn off neurotic self-criticism and increase enthusiasm in preparation for creative tasks, or set a timer on our grief in response to tragic events. Beta-blockers are being used to control performance anxiety, and oxytocin can be manipulated to increase trust, bonding and empathy. As David Pearce has advocated (Pearce, 1998), many of our descendants will experiment with turning down their experience of pain and jacking up their experience of happiness and pleasure, and we will have to navigate, individually and socially, the land-of-the-lotus-eaters pitfalls.

d. Controlling addictions and moral failings, and augmenting our capacities for moral self-control, sentiment and cognition

A priest's collar, a chastity belt, a hairshirt, an ankle monitor on a parolee, a video monitor on a police cruiser, or a porn filter on a library computer can all be seen as crude forms of moral augmentation. But as our understanding of the neurological basis of self-control, empathy, fairness and moral decision-

making grows, we have begun to experiment with neurological therapies for moral failings. Stimulants allow those who would formerly been labeled "bad children" or lazy adults to develop attentiveness and conscientiousness. Pedophiles and rapists are being treated with testosterone suppression to modulate their compulsions. The neurological miswirings and neurochemistries that impairs understanding of others' emotions in autism, or the desire to harm others in psychopathy, may be repairable. The relationship of an over-active amygdala in moral cognition, firing powerful signals of fear and disgust that overwhelm more rational decision-making, has been found to be amenable to modulation with propranolol, meditation, SSRIs and alcohol. Risk-taking and addiction-proneness have been found to be related to variations in dopamine genes suggesting that these traits could be changed pharmaceutically, and vaccines have been developed to block the effect of cocaine, opiates, nicotine and alcohol.

As with other forms of enhancement, however, our capacity to modulate our vices and virtues with exocortical systems will likely be more popular and accessible. Wearable sensors of exercise and blood glucose will have fewer side-effects than bariatric surgery, or drugs and gene therapies to regulate muscle growth and fat metabolism. Electronic reminders will be more accessible than cognitive enhancement drugs or brain prostheses to help remember birthdays. Electronic checklists that nudge us towards wiser choices are safer and more transparent than drugs or devices to change decision-making neurons directly. Eventually these exocortical forms of self-control will combine with our pharmaceutical methods and our brain-machine interfaces to allow us – and state authorities, religious institutions and military command structures – full access to our moral feelings, decision-making and behavior.

e. Exploring and augmenting our capacity for spiritual experience

Ordinary, waking awareness is just a small fraction of the states of consciousness that we are capable of experiencing, and our future augmented brains will have even more states to consciously and intentionally explore. Shamans, yogis and monastics have been experimenting for tens of thousands of years with spiritual technologies, from drugs, chanting and meditation to yoga and sweat lodges. Today the scientific study of psychedelic drugs is documenting that they can create long-lasting positive changes in personality (MacLean, et al., 2011), and may be adjuncts therapies in overcoming depression, PTSD, and addictions. Meditators are being studied with fMRI, and studying themselves with portable consumer EEG monitors, documenting changes in brain structure, mental health and behavior. Transcranial magnetic stimulation is being used to manipulate parts of the brain controlling proprioception, generating experiences of "oneness." Just nano-neural interfaces and brain-machines will enable increasingly precise control of memory, attention, cognition and emotion, it will also enable easier and deeper experiences of awe, oneness, timelessness, gratitude, and meaning.

3. Social systems

Together these various forms of ancient, ongoing and impending augmentations and enhancements mean that we have long been in a "transhuman" era, transitional from the Paleolithic human existence to the

myriad posthuman forms to come. When exactly we entered this condition is as unclear as when we will leave it, since the line between ur-human and modern human is contested, and our uploaded, gene-tweaked cyborg descendents will have as much claim to the mantle of "human" as an eye-glass wearing woman with a prosthetic leg does today. But instead of having centuries to adapt, the accelerating adoption of physical, cognitive, sensory and spiritual augmentation will drive as much change in our social life in the coming decades as we have seen in centuries.

a. Family and reproduction

There is already a trend towards lower rates of marriage and smaller families in the industrialized world. One reason for this trend is that, with the decline of agricultural labor and the banning of child labor in factories, children have become an increasingly expensive luxury. As a consequence there has been a growing concern with ensuring that the few children a couple will produce have the best possible opportunities in life. The desire to maximize children's life prospects is driving the use of prenatal testing, and will in the future drive an interest in preconceptive testing and gene therapies to ensure children's health, abilities, and attractiveness. Just as ensuring that children are literate has been a social and parental obligation, so ensuring that they have access to and literacy with the rapidly evolving exocortex of information and communication technologies is obligation today. Similarly as genetic, nanomedical and brain-machine enhancements become more common and expected in education and employment we will be obliged to ensure that children have them.

There are several aspects of enhancement and augmentation that may mitigate the decline of marriage and child-rearing. First, increasing the proportion of the population who are healthy and able-bodied, and lengthening the span of their lives, means that more people will be able to find attractive life partners and they will have increasingly amounts of time in which to find them. More direct control over the neurochemistry of love, lust, trust and neuroticism will make it easier for us to be more agreeable and faithful life partners. The growing options for reproduction will also mean that being infertile, single, post-menopausal or homosexual will be increasingly irrelevant to starting a biological family. Eventually the artificial womb will make it possible to have children without the complication of a surrogate mother. There has been little evidence thus far, however, that even the most optimal pro-natal policies in Northern Europe - state-sponsored IVF, gay marriage, generous family leave and free higher education - have reversed the trend of declining marriage and child-bearing.

One form of augmentation that will likely accelerate this decline is the electronic mediation of sexuality. For those who still desire physical encounters, computer dating, Grindr and Facebook apps like Bang With Friends have facilitated commitment-free hook-ups. There is also substantial evidence that for many people pornography substitutes for sex in the flesh, and the rapid proliferation of myriad forms of Internet pornography is now being integrated with haptic devices and immersive virtual reality. Electronically mediated sex is safer (no diseases, violence or pregnancy), easier (no lengthy courtship, commitments or foreplay), and can be exactly what the individual desires (your partners can be anyone, or anything, you desire, without any physical defects). In *Love and Sex with Robots* David Levy (Levy, 2008) argues convincingly that there will also be a large market for robotic surrogates for sex and eventually romantic relationships.

Even the most fundamental categories of our reproductive system, the gender binary, will continue to erode in the coming century, a process that began with industrialization (Hughes & Dvorsky, 2008). With gene therapies and tissue engineering it will become easier to modify genitals and hormones, and post-secondary sex characteristics like breasts, vocal chords, and body hair. Subcultures are already exploring gender identities and morphologies liminal between male and female, and forms of augmented hypersexuality and asexuality will be possible.

b. Education

Already alternatives to the factory-era of primary school education and the medieval models of higher education are being explored with computerized, self-guided learning modules, massive online courses, and skill certification. Meanwhile cognitive enhancement drugs, access to ubiquitous computing, and eventually brain-machine interfaces will be speeding up the learning process. We will increasingly depend on our intelligent personal assistants as extensions of our own memory and cognition, cataloguing our life experiences, collecting information, and summarizing and prioritizing choices. The rapidly changing, shrinking, and harshly competitive labor market will mean that increasingly numbers of adults will be engaging in continuous up-skilling as they attempt to remain employable.

c. Work and the economy

In the context of an overall decline of employment due to automation and disintermediation, and the growing number of healthy senior citizens staying in the labor force, there will be greater competition for a declining number of jobs. Workers with the latest physical and cognitive enhancements will likely have far greater advantages in that competition, just as healthy and computer-literate workers are advantaged today. Likewise countries that facilitate more widespread access to physical and cognitive augmentations, and the time to learn to use them, will be more productive. The most automated economies and workforces will need to adopt policies that ensures a broad redistribution of income, leisure and access to remaining employment opportunities in order to maintain economic growth and competitiveness.

d. Religion

Few religions have objections to medical therapies and prosthetics. So, as the normative standard gradually moves, there will likely be few religious objections to the extension of physical, sensory and cognitive abilities, at least until augmentations begin to challenge moral intuitions about human/non-human boundaries. We can see some of the contours of this conflict in religious objections to reproductive technologies and human-animal chimera research. The Abrahamic faiths – Judaism, Christianity and Islam - in general are resistant to radical versions of the cyborg project, seeing it as an affront to the divinely created human body's role in the divine project. Proposals to record and upload human personality are most problematic, as they adopt a purely materialistic model of human consciousness.

Asian religions are likely to be more accommodating of augmentation however. Faiths such as Buddhism and Hinduism, on the other hand, are more open to the idea of individual minds migrating from animal to human to superhuman bodies. There also is more enthusiasm for human enhancement projects like genetic enhancement in the societies from India to Japan than in Europe and North America.

Religious institutions will similarly react in a variety of ways to widespread access to neurotechnologies that control moral feelings and behavior, and provide access to previously rare religious experiences. Some will accept neurotechnologies, or even incorporate them into their practices as obligations and sacraments, while others will reject them as distractions and abominations. The more puritanical faiths will likely find more use for technologies for moral self-control, while Buddhism, Hinduism and shamanic traditions may find ready use for new methods of inducing altered states of consciousness.

e. Politics and global conflict

As I proposed in *Citizen Cyborg* (Hughes, 2004) conflicts over the cyborg project are likely to increasingly shape political conflict in the 21st century, with bioconservatives of a variety of stripes aligning against an increasingly diverse coalition of bioliberals and transhumanists. One central debate will be the significance of genetic and morphological "humanness" as the basis of rights-bearing, as opposed to self-awareness and cognitive capacities. This argument has already shaped the status of fetus and the brain-dead, and in the future it will be central to the struggles over the rights of cognitively enhanced animals, genetically modified and cyber-enhanced humans, and machine minds.

A second key element of the public policy debate will be the relevance of the therapy/enhancement distinction. Just as many now feel that stimulant drugs for ADD and SSRIs for depression represent widespread over-medicalization of the normal human condition by a profit-driven medical industrial complex, demands for increasingly sophisticated augmentations by able-bodied citizens will make clear the arbitrary nature of the therapy/enhancement line. Bioconservatives will resist the increasing informal or overt pressures from educators and employers to adopt augmentation, just as there is resistance today to "coercion" to abort disabled embryos or be electronically accessible 24/7.

Struggles over the funding of enhancement research, and the regulation of enhancements and augmentations, will take place on the pre-existing terrain of growing inequality and geopolitical competition. Over the last fifty years we have been increasingly using state-financed healthcare systems to expand access to assistive technologies - from renal dialysis and wheelchairs, to cochlear implants, IVF and stimulant drugs - and demand for equitable, publicly-financed access will grow. Countries that do not support the enhancement of their workforces will be at an economic disadvantage internationally, and militaries that do not fully exploit robotics, drones and supersoldier enhancement will be at a military disadvantage.

On the other hand, just as transnational institutions like the International Atomic Energy Agency have grown in importance to stem the proliferation of weapons of mass destruction, preventing the super-empowerment of individuals and small groups with forms of human augmentation will increasingly become a concern for nation-states and transnational policing. As has been the case with nuclear energy and chemical weapons, however, the "dual uses" of augmentation technologies will make effective transnational regulation very difficult. Just as China may consider unfiltered access to the Internet to be a threat to national security while the West sees it more as a basic right, some countries are likely to resist efforts to ban enhancements and augmentations and attract an international medical tourist traffic seeking them.

4. Future direction and learning more

We know from the history of futurological speculation that we are rarely right about the pace of innovation and its consequences. Technologies which seem imminent may never come to fruition, while technologies like the Internet may be inconceivable. The first order effects of technological innovation – such as automobiles leading to high-speed accidents – may be foreseen, but secondary and tertiary effects – such as the spread of suburbs, climate change and the decline of the trolley – are harder to imagine. Likewise with augmentation it is likely that some forms of augmentation will remain impossible, too expensive or unappealing, while new forms will emerge with unimaginable consequences. This is why I have focused less on the plausibility and timelines of different types of augmentation in this essay, and more on the human capabilities towards which all forms of human engineering are likely to be applied. Assuming that these broad goals of control of the body and brain will be accomplished one way or the other, we can then focus on what consequences these forms of control may have on society.

A second thing I have attempted with this essay is to expand the frame on enhancement and augmentation to include the technologies we have co-evolved with for hundreds and thousands of years. Debates over the social impacts of technology are too often ahistorical, ignoring that previous technologies were greeted with similar hype and hysteria, and raised the same ethical and social questions. By keeping this continuity in mind we can often extrapolate that we will accommodate new innovations with the same moral codes and regulatory structures. It may be that cyborg augmentation or the "Singularity" may eventually pose practical questions that were only philosophical thought experiments in the past, needing entirely novel responses, but thus far the social and regulatory challenges appear manageable within the social institutions we already have.

The academic, policy and lay communities that contribute to the global discussion of the social implications of human enhancement and augmentation are too diverse to enumerate fully. The communities that I have participated in have been those of public policy, bioethics and transhumanism. One of the key bioethics works raising bioconservative concerns about human augmentation was *Beyond Therapy: Biotechnology and the Pursuit of Happiness* (President's Council on Bioethics, 2003), while the collections *Enhancing Human Capacities* (Savulescu, et al., 2011) and *Human Enhancement* (Bostrom, et al., 2011) represent many of the bioliberal voices. Two works that represent the transhumanist movement's perspectives are *The Singularity is Near* by Ray Kurzweil (Kurzweil, 2006) and *The Transhumanist Reader* (More, et al., 2013). Two key historical documents in the imagination of human-machine integration and the cyborg are J.D. Bernal's 1929 essay on the future of prosthetically enhanced humans *The World, the Flesh and the Devil* (Bernal, 1969) and Clynes and Kline's essay coining the term "cyborg" (Clynes & Kline, 1960). Other important literatures are those of artificial intelligence and cognitive science, life extension and bioscience futurism, the emerging literatures on global catastrophic risks and the economic effects of automation, and general futurist speculation including speculative fiction.

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