The Living Prosthesis: Limits of Human Bearability

Published by

Ferracina, Simone.
Œ Case Files, Vol. 01.
Punctum Books, 2021.
Project MUSE. https://dx.doi.org/10.1353/book.84314.

The Living Prosthesis: Limits of Human Bearability

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Technology enhances aspects of a user's life and mediates our perception of reality; changing the way we understand the world. The use of wireless networks in mobile devices, for instance, causes us to always carry around a piece of technology that enables us to have access to additional information and to engage in social networking while on the move. CCTVs and wireless location systems also ensure constant surveillance of users by tracking their location in real time (Manovich 2006). Sensing of bodily data in affordable consumer products like oximeters provides information about one's body in quantifiable measures. Embedded medical devices such as pacemakers, which use sensors to monitor the heart and trigger actuators that regulate its beat, have the purpose of life preservation. What is currently missing is a systemic combination and integration of the disparate technologies that are found attached to or embedded into the human body, one that could point towards the wearable and bearable technology that will fulfill our needs in the future.[1]

The limit to which human behavior can be altered with such implantable or body-borne devices during interaction with and inhabitation of the environment, is also changing. This raises questions about the infringement of a user's privacy and subjective perceptions, the merging of our virtual and physical spaces, and the ethical issue of implanting such technological devices into the body. When technology becomes invasive, who is in charge, the user or the prosthesis? In the circular exchange of information between human and machine, where both are driven by their own teleological mechanisms, there will be instances where machine dominance and human subservience occur.

1 —
The term "wearable prosthesis" refers to computers worn under or in the clothing, and can also indicate items of clothing. The term "bearable prosthesis" refers to implantable, portable or body-borne computers that are embedded on or in the body. See Mann (2013).

Attachment to the Human Body

The relationship between a prosthesis and a user is primarily that of an attachment to the body, or of an extension of the body to supplement a deficiency (Wigley 1991). As the prosthesis is used to enhance or counter a weakness in the user's biological body, the technological side of the device could be said to imitate biology, and be seen as a form of substitution. One example might be a deaf man fitted with haptic prostheses to supplement his loss of hearing (Wiener 1951), or a patient with a prosthetic limb.

In a philosophical sense, the prosthesis is part of an extended mind. As discussed by Andy Clark and David Chalmers, cognition consists of both bodily movements and brain processes, and "does not limit itself within the physical brain or skull" (Clark and Chalmers 1998). Chalmers uses the term "active externalism" (1998, 7) to describe the use of external supplements, such as language or technological tools (for instance, a pocket calculator) that engage bodily movements. In this context, the prosthetic device and the body can act as an external coupling system integral to the cognitive process. As discussed by Mark Wigley, a similar view was held by Sigmund Freud, who had personally experienced wearing a prosthetic jaw for a period of time (Wigley 1991). Freud sees the body as deficient and defines the mind as the site where consciousness is constructed. In this perspective, the aim of the prosthesis—similar to the natural body and its senses—is to extend the boundaries of the mind and aid in the construction of consciousness.

In an architectural context, a prosthesis is an extension, "an auxiliary organ" that supplements a gap in the main body (Le Corbusier 1987, 72). Le Corbusier argues that humans are born with insufficient capabilities. We do not have the natural ability to fight predators, to withstand harsh weather, and hunt or fight for food (1987); we tend to forget things easily and we are ashamed of our appearance. Apart from physical limitations—notes Le Corbusier— humans are also not adequately motivated mentally, and are often more interested in leisure than in intellectual or productive work. We are frequently too lazy to carry out tasks that require attention and laborious concentration. Hence we acquire tools such as shelter, clothes, cabinets, food containers, computers and robots to carry out the actions that we are unwilling or incapable of attending to. All these, including architecture, become a form of prosthetic extension of our deficient body.

The notion of prosthesis discussed above describes a symbiotic relation between the technological device and its user. Mark Wigley argues that both supplement each other's deficiency. Relating it to the use of a computer mouse, he notes that both the mouse and the user employ the other as a prosthetic extension to access the digital system of the computer (Wigley 2010). Together, they form an interface to the virtual world. Doug Engelbart, who invented the mouse, indicates that the most functional interface is achieved when the user's central nervous system is able to match the outer environment through his senses (Engelbart 1962).

Therefore, the technological prosthesis evolves with the body, engendering a new form of behavior. Here, the effect of a prosthesis goes beyond the extension of bodies at a specific time; one begins to be affected by a prosthetic device before, during and after usage (Wigley 2010, 51). Andy Clark and David Chalmers discuss this with regards to the requirement of a reliable coupling system to enable a prosthesis to form part of an extended cognition system. "If the resource of my calculator or my Filofax are always there when I need them, then they are coupled with me as reliably as we need" (1998). In order for a prosthesis to form a seamless connection with our mind, that is, the memory of the effect and prosthetic experience matters more than the duration of its actual use. When we become accustomed to the presence of a prosthesis on us, its subsequent removal might incur more deficiency to our body than was experienced prior to its annexation. In the case of medical prostheses, removal might even result in the endangering of life itself (Clark and Chalmers 1998).

The Role of Prosthetic Devices From the Past to the Future

Mark Wigley writes, with regards to the invention of the computer mouse, that "[a] history of 20th century prosthetics can be written in terms of the ever smaller movements of the fingers that have ever greater effects over ever larger domains" (Wigley 2010, 51). Human behavior can also be seen evolving as a result of the introduction of domesticated technological appliances in the 1960s. In the case of the mouse, movement across a horizontal surface is translated into visual motion across the virtual screen, augmenting the user's gestures. Having become a reliable coupling system in the user's perception, the prosthesis can be subconsciously interacted with on a daily basis.

Our engagement with the environment has become more personalized, portable and encapsulated within a non-physical layer that is seemingly attached to the body. This layer—the so-called virtual world— is accessed through computers and prosthetic devices such as mobile phones. Our experiences become mediated as we begin to understand the physical environment through the virtual information layered onto the body's natural sense perceptions.

In order to further domesticate technological prostheses, the corresponding interfaces require progressively smaller movements and fading visibility. Because a user-computer interface is "at once technological and biological" (2010, 53), it involves the alteration of our behavior (expanding the human ecosystem) in order to communicate with the electrical circuitry and signals that create the digital world (expanding virtual environment). Through this, the user and machine can establish a common ground, enabling the user and the digital space to enter each other's world. As a result, prosthetic technology has become more intrusive and pervasive. Intelligent agents that come in the form of technological appliances constantly track the health, mood and safety conditions of their owners, reminding and advising us when to take pills, what to wear or when to exercise— augmenting our private behaviors (Poslad 2009). The boundary between the user's privacy and the sharing of information for his welfare continues to be blurred.

Prosthesis as Reality Mediator

David Chalmers discusses the term "reality" as dependent on the act of being conscious—"I think, therefore I am conscious" (Chalmers 1995). From his viewpoint, reality is the construction of the environment on the basis of individual experiences. Following this account, consciousness is part of the cognitive process.[2] If we relate this to the formation of a reliable coupling system between a prosthetic device and a user as part of an extended mind (Clark and Chalmers 1998), it becomes clear that when a prosthesis is fitted onto the body it is granted the ability to affect the user's perception of reality.

From a cybernetic point of view, Heinz Von Foerster defines the term "reality" in relation to the human discovery of things such as language, and claims that these discoveries comprise the user's cognition (Von Foerster 2003). As he argues, "it is he [the observer] who invents it, and, likewise, when we perceive the environment, it is we [the observers] who invent it" (2003, 211). The term is broken down to become an "operation of recursive descriptions" in the user's mind, made possible by continuous discoveries (2003, 216).

Doug Engelbart, who deals specifically with virtual reality as the simulated space displayed by computers, speculates on a future where computer-user interfaces can be established directly through the user's brain, bypassing bodily senses (Engelbart 1962). This suggests that sense perceptions help the mind construct the environment, forming the individual's reality.

If reality is constructed by an individual's perception of the environment, why is it that most commodities produce similar sets of reactions in different individuals? Heinz Von Foerster argues that an individual's reality is made up of a community of other individuals' realities, as we interact with an environment that is comprised of other observers. This establishes a certain common ground, allowing us to have similar associations. He refers to the "reality = community" formula, suggesting that there are other individuals with their own perception of reality in the environment, and that these make up a certain set of similarities (Von Foerster 2003). "If you desire to see," he writes, "learn how to act" (2003, 227). It can be therefore said that our individual reality is made up of the perceptions acquired while interacting with other individuals in the environment.

2 —
According to Clark and Chalmers, cognition consists of both bodily movements and brain processes (Clark and Chalmers 1998).

This perspective is supported by contemporary theorists such as Lev Manovich, who discusses the contemporary notion of reality as a database, where a user perceives the environment through the "world wide web filled with ever-changing data, images, texts" contributed by users around the globe who engage with the internet (Manovich 2002). Reality is then defined by the data that the internet provides to the user, which is information created through the realities of other individuals.

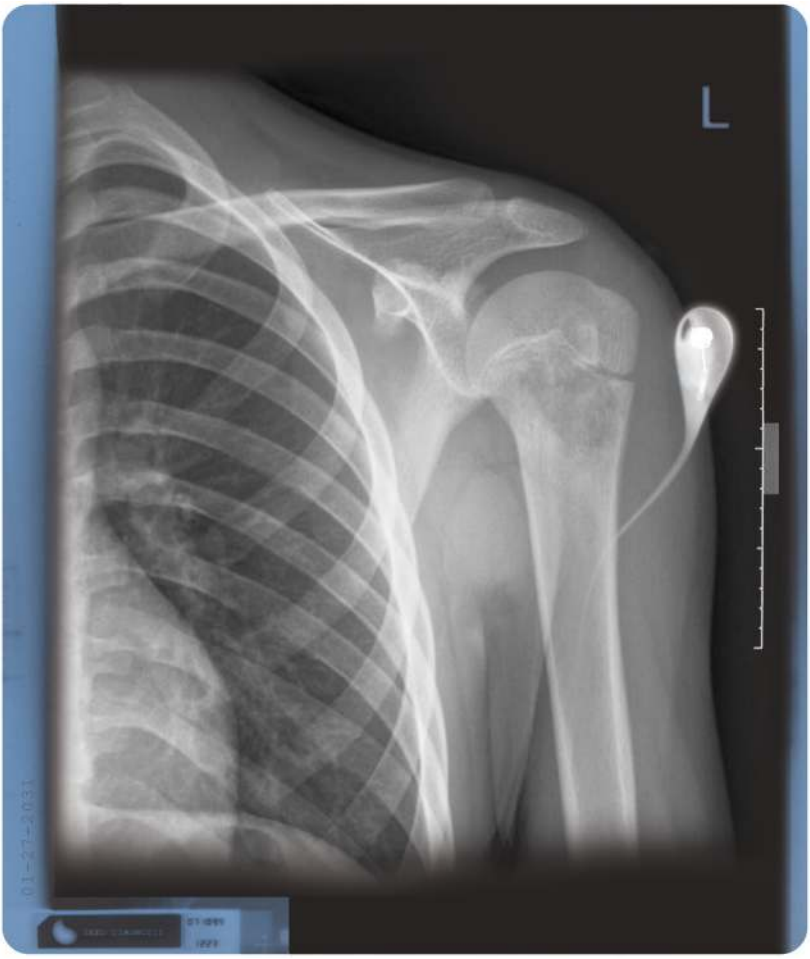
Reality can then be concluded to be a construct of the user, made up of sense perceptions and of observations, discoveries and interactions with many different entities. Therefore, our reality can be easily influenced and altered by external stimuli and has the potential to be mediated.

Steve Mann coined the phrase "Mediated Reality" to describe a type of reality experienced through technological devices attached to the body. Such prosthetic devices are used for "augmenting, deliberately diminishing, and more generally, for otherwise altering sensory input" (Mann 2010, 1). As Mediated Reality involves a wider spectrum of bodily senses, it has a greater impact on the user than Augmented Reality, which is commonly experienced only through the user's visual field.[3]

The *Reality Mediators* project investigates the effects of Mediated Reality on the user and on his interactions with the environment. It consists of three sets of design experiments that seek to explore the degree of disruptiveness generated by active goal-based technological prostheses. The three sets of experiments employ three different types of sensors: muscle sensors, brainwave reading devices and Global Positioning Systems (GPS). These are paired separately with four types of actuators, such as muscle stimulators, sound actuators, heat pads and vibration motors, fitted onto different parts of the body. Their cumulative outputs produce an inherently unpleasant effect on the user, which is measured in terms of its disruptiveness to everyday activities.

3 —
Augmented Reality refers to the overlaying of dynamically changing informtion in the form of multimedia, enhancing the user's visual field (Manovich 2006).

Ling Tan, *Reality Mediators*, 2013. Top: Mindwave device detecting brain wave activities. Middle Left: Microchip translating the biodata collected from the user's body. Middle Right: Muscle sensors detecting arm muscle activity. Bottom: Sound actuator fitted on back on ear.



Ling Tan, *SEED*, 2013. Have you considered the intake of new sets of nutrients to grow *SEED* according to your desired outcomes?

Prosthesis as an Artificial Intelligence

In a technologically advanced society, surveillance and intervention must form a symbiotic relationship. Lev Manovich contextualized this argument with regards to the emergence of Augmented Space in the form of the internet, wireless location systems, mobile phones and digital displays (Manovich 2006). "By tracking the users—their moods, pattern of work, focus of attention, interests, and so on—these interfaces acquire information about the users, which they then use to automatically perform the tasks for them" (2006, 222).

The future of technological prostheses can then be hypothesized to be that of an artificial intelligence having its own understanding of the environment and of users. Through prolonged periods of coupling with the user, it is able to learn and adapt to their preferences, and starts to dictate the user's reality (perception and autonomy) through the effects produced.

The *SEED* project surveys the possibility of bearable prostheses as commodities. It speculates on a future where embedded prostheses form a symbiotic relationship with the user's body, taking on and modulating their genes through prolonged periods of growth and interaction.

Ling Tan, *SEED*, 2013. Sign of healthy growth has been detected.

Limits of Human Bearability

Paola Antonelli defines the term elasticity as "the by-product of adaptability + acceleration" (Antonelli 2008, 14). Elasticity is characterized by our ability to embrace fast-changing advancements and to capitalize on them for our own purposes. Our brain develops in a way that adapts to external tools, enabling them to become part of an extended cognition. One example is the sensory prosthesis created by Norbert Wiener, designed to replace loss of hearing with the sense of touch through a device that sends electrical vibrations to the fingers (Wiener 1951). After wearing the prosthesis for a prolonged period of time, a deaf user is able to mentally translate the language of the electrical vibrations—its rhythm and intensity—and to understand what the speaker is saying.

It can be concluded that our mind is simultaneously elastic and sensitive, in order to reject or accommodate changes in the environment. In the case of a bearable prosthesis, if a reliable coupling is formed, the mind is elastic enough to adapt and make full use of the device, allowing it to become part of a system of extended cognition. If anything during the process causes the user to receive an unpleasant feedback, the mind is sensitive enough to reject the device. However, my experimental tests show that if the unpleasant feedback happens after a prolonged duration of bearing the device, the mind becomes uncertain as to whether it should reject or accept it, and chances are it will accept it. Hence, what makes a prosthesis more or less bearable for the user is not so much the extent of physical pain imposed by the device, but rather its effects in the long run.

While we can measure the degree to which technology transcends physical and physiological boundaries, we can only speculate about the ethical consequences of these developments and their effects on human self-perception. Although wearable and bearable devices are still at an exploratory stage, these debates are already on-going, highlighting problems like the infringement of privacy involved in sharing users' biodata, the possibility (and consequences) of such symbiotic devices being hacked and stolen, and the potential addiction to the effects produced. As researchers and designers, we must address and investigate these topics before such invasive technologies are integrated into our everyday lives. As users, we must expand our understanding of the environment as comprising physical space as just one among many layers of reality.

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Acknowledgments

Special thanks to Ruairi Glynn, Head of The Bartlett's Interactive Architecture Lab, for the support and guidance provided throughout the research process. I would also like to thank my friend, Chryssa Varna, for modeling for my project.

Photography by fashion photographer Chiara Ceci.