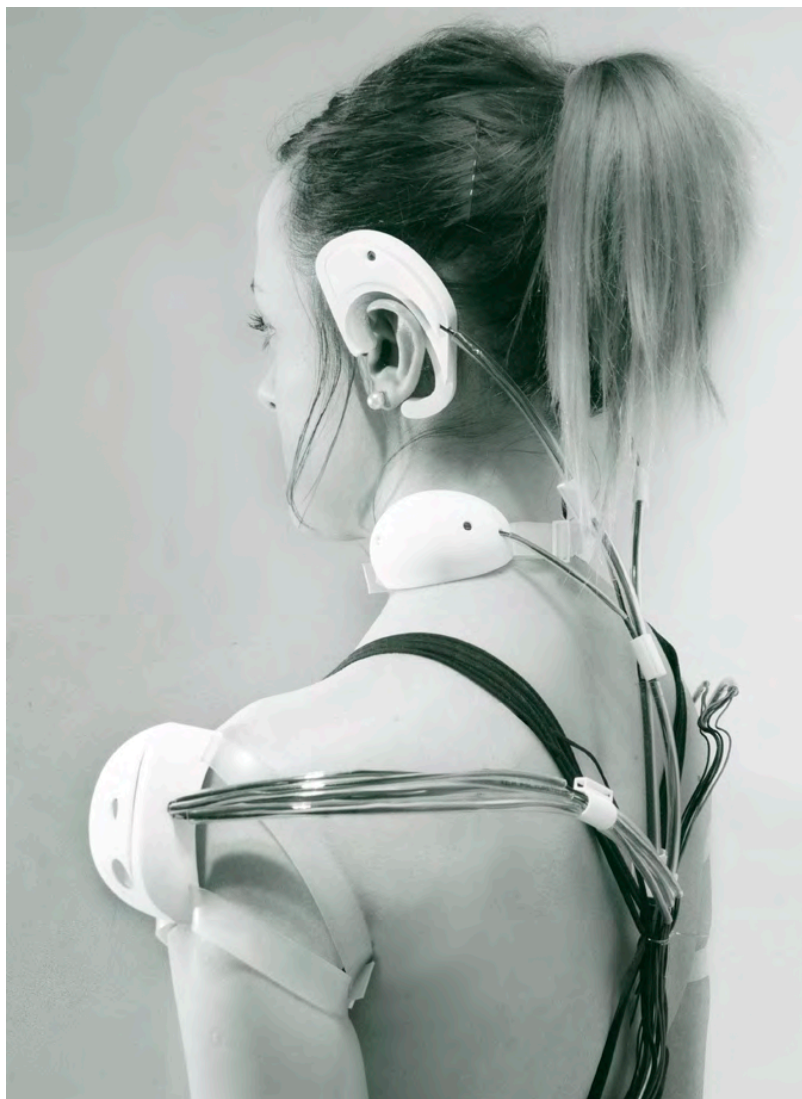


The Living Prosthesis: Limits of Human Bearability

Ling Tan



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.¹ 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

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Lev Manovich, "The Poetics of Augmented Space," in *Visual Communication* 5.2 (2006): 219-40.

the wearable and bearable technology that will fulfill our needs in the future. 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.

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.²

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,³ 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".⁴ Chalmers uses the term "active externalism"⁵ 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.⁶ 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"⁷ that supplements a gap in the main body. 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;⁸ 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

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Mark Wigley, "Prosthetic Theory: The Disciplining of Architecture," in *Assemblage* No. 15, (1991): 7-29.

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Norbert Wiener, "Problems Of Sensory Prosthesis," in *Bull. Amer. Math. Soc.* 57 (1951), 27-35.

4—

Andy Clark and David J. Chalmers, "The Extended Mind," in *Analysis* 58, (1998): 10-23.

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Clark and Chalmers, *ibid.*

6—

Wigley, "Prosthetic Theory."

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Le Corbusier, *The Decorative Art of Today* (Cambridge, MA: MIT, 1987).

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Le Corbusier, *ibid.*

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,⁹ he notes that both the mouse and the user employ the other as a prosthetic extension to access the digital system of the computer. 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.¹⁰

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.¹¹ 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."¹² 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.¹³

The Role of Prosthetic Devices From the Past to the Future

Mark Wigley writes, with regard 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."¹⁴ 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,"¹⁵ 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

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Mark Wigley, "The Architecture of the Mouse," in Oliver Sacks, *The Mind's Eye* (New York: Alfred A. Knopf, 2010), 50-57.

10—

Doug Engelbart, *Augmenting Human Intellect: A Conceptual Framework* (Menlo Park, CA: Stanford Research Institute, 1962).

11—

Wigley, "The Architecture of the Mouse."

12—

Clark and Chalmers, "The Extended Mind."

13—

Ibid.

14—

Wigley, "The Architecture of the Mouse."

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Ibid.

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,¹⁶ reminding and advising us when to take pills, what to wear or when to exercise— augmenting our private behaviors. 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").¹⁷ 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. 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,¹⁸ 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,¹⁹ and claims that these discoveries comprise the user's cognition. 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."²⁰ The term is broken down to become an "operation of recursive descriptions"²¹ in the user's mind, made possible by continuous discoveries.

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.²² 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,²³ 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. "If you desire to see," he writes, "learn how to act."²⁴ It can be therefore said that our individual reality is made up of the perceptions acquired while interacting with other individuals in the environment.

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"²⁵ contributed by users around the globe who engage with the

- 16—
Stefan Poslad, *Ubiquitous Computing: Smart Devices, Environments and Interactions*. (Chichester, U.K.: Wiley, 2009).
- 17—
David J. Chalmers, "Facing up to the Problem of Consciousness" in the *Journal of Consciousness Studies* 2(3) : 200-19, 1995.
- 18—
Clark and Chalmers, "The Extended Mind."
- 19—
Heinz Von Foerster, *Understanding Understanding: Essays on Cybernetics and Cognition* (New York, Springer: 2003).
- 20—
Ibid.
- 21—
Ibid.
- 22—
Doug Engelbart, *Augmenting Human Intellect*.
- 23—
Heinz Von Foerster, *Understanding Understanding*.
- 24—
Ibid.
- 25—
Lev Manovich, *The Language of New Media* (Cambridge, MA: MIT, 2002).

Reality Mediators.

Top—

Mindwave device detecting brain wave activities.

Bottom Right—

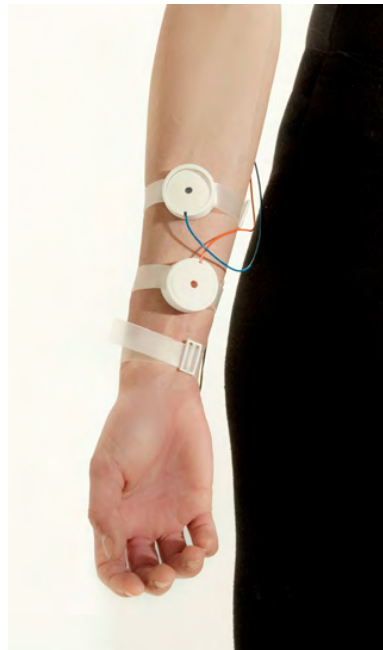
Sound actuator fitted on back on ear.

Bottom Center—

Muscle sensors detecting arm muscle activity.

Bottom Left—

Microchip translating the biodata collected from the user's body.



internet. 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."²⁶ As Mediated Reality involves a wider spectrum

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Steve Mann, "Cyborg unplugged: Some ecological issues of wearable computing and personal safety devices," 2010. Available at <http://wearcam.org/unplugged.pdf>.

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.

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.

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 Space²⁷ in the form of the internet, wireless location systems, mobile phones and digital displays. "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."²⁸

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 his 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.

Limits of Human Bearability

Paola Antonelli defines the term elasticity as "the by-product of adaptability + acceleration."²⁹ 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.³⁰ 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

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Lev Manovich, "The Poetics of Augmented Space."

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Ibid.

29—

Paola Antonelli, *Design and the Elastic Mind* (New York, Museum of Modern Art: 2008).

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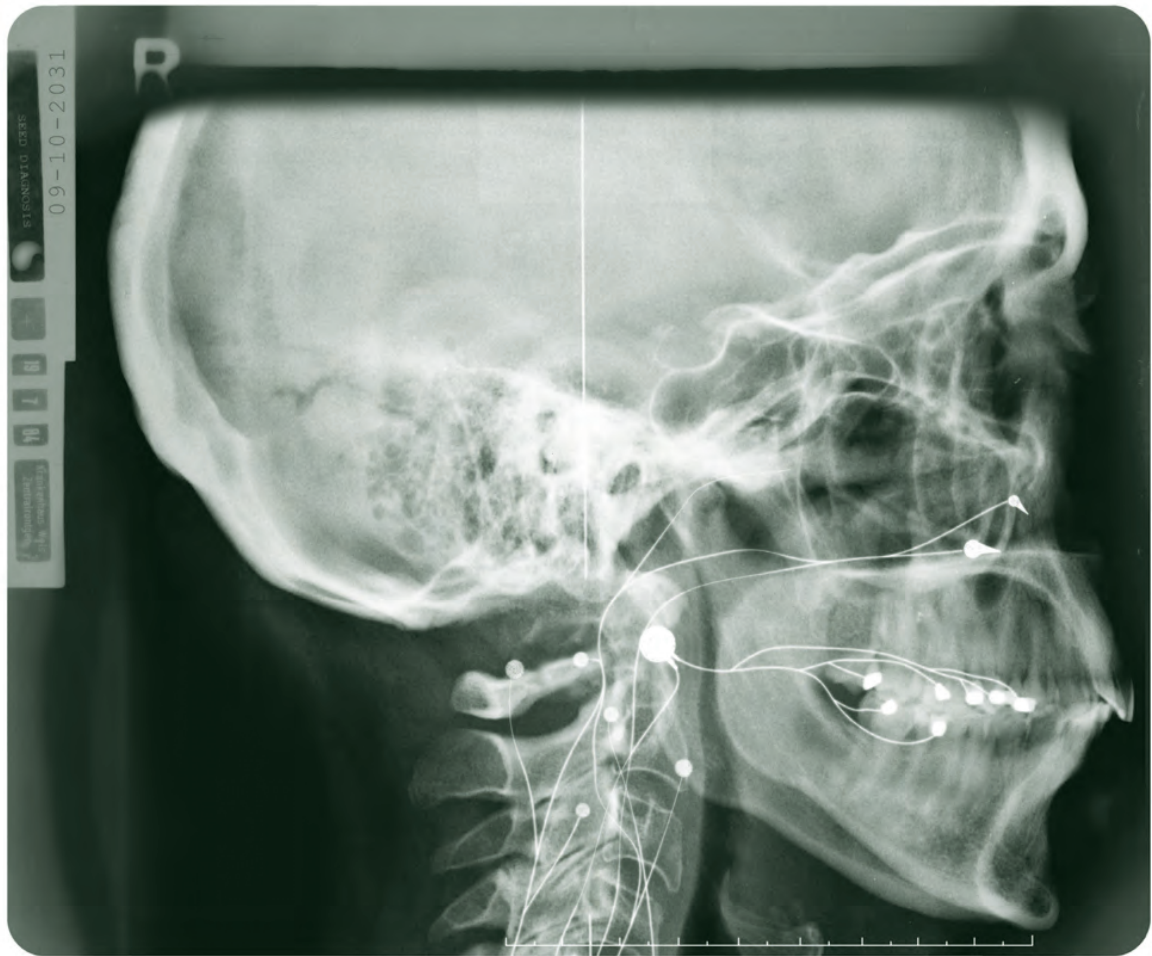
Norbert Wiener, "Problems Of Sensory Prosthesis."



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

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.

SEED project by Ling Tan. Sign of healthy growth has been detected.

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