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SECOND-ORDER PROSTHESIS

Human-aided design within the expanded field of ecology

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Abstract. This paper defines second-order prosthesis in which the human subject, by virtue of her corporeality or imagination, is resourced by a technological system. Underpinning this definition is Massumi's notion of asymmetrical, symbiotic prosthesis and the second-order cybernetic challenge to objectivity. Through the case study of an immersive, sensor-based, interactive artwork, it is found that there are resonances between technology engaged in second-order prosthesis and the ideology of biology. Notions of survival, reproduction and evolution become a critical part of second-order prosthetic discourse and an expanded field of ecology is identified as the territory of analysis for resulting techno-human relations. A second case study explores computer-aided design (CAD) and virtual space. This study confirms the status of the technological in an expanded ecology as both CAD and virtual space resource imagination in the production of human-aided design.

Keywords. Second-order prosthesis; expanded ecology; prosthesis; computer-aided design; human-aided design.

1. Illusory objectivity and second-order prosthesis.

Fundamental to the arguments presented in this paper is a challenge to objectivity and the validity of the scientific method. Heinz von Foerster articulated the absurdity of objectivity in its insistence that *"The properties of the observer shall not enter the description of his observations"* (Foerster, 1979). The problem he identifies is that the observer is the condition upon which a description can be made. Further, Foerster is critical of the scientific method for its crude and reductive tenets, firstly that a rule established on past events

will always hold for the future and secondly, that once a cause has been identified, *"everything else in the universe shall be irrelevant"*. Instead he insists, *"we have to observe our own observing and ultimately account for our own accounting"*. (Foerster, 1979) In such a frame of reference, looking at an arrangement of numbers or letters in a particular order, it becomes clear that an emerging order is not an objective property of the object but rather the result of a subject-object relationship.

The field of second-order cybernetics, which Foerster was seminal in establishing, acknowledges that a study of communications and control systems, organic and/or inorganic must recognise that any observations made cannot be considered purely objective but rather constitute an analysis of a system *as analsyed by an observer*; observations are relational constructions. These arguments resonate with the more recent writing of Brian Massumi in "The Evolutionary Alchemy of Reason". Massumi writes *"Perception lies between the perceiver and the perceived."* (Massumi, 2002) Massumi challenges notions of objectivity further:

> " The flower-thing is all of the thought- perceptions in which it is implicated. Latent in the flower are all of the differential conjunctions it may enter into. The flower, as a thing "in itself", is its connectability with other things outside of itself."

Here Massumi denies any possibility of disconnecting a "thing" from its world or context. The "thing" is only its potential relations to other things. Massumi takes his critique of objectivity to its extreme:

> "The thing is its being-perceiveds. A body is its perceivings. "Body" and "thing" and, by extension, "body" and "object" exist only as implicated in each other. They are differential plug-ins into the same forces, two poles of the same connectability. The thing is a pole of the body and vice versa. Body and thing are extensions of each other. They are mutual implications: co-thoughts of two-headed perception. That two-headed perception is the world… Extensions. The thing and the object can be considered prostheses of the body – provided that it is remembered that the body is equally a prostheses of the thing." (Massumi, 2002)

If one takes seriously the claim that observations and perceptions are subject-object relations, an ontological redefinition takes place, body and object are co-defined in a world inter-related by potential connectivities. There is no thing-in-itself, nor an objective thing; rather, we discover bodies as organs of objects and vice versa.[1] This perspective gives the framework of objectivity a dreamlike and illusory status. Massumi highlights the two-sided nature

of prosthesis between body and object giving the example of a mass-produced pharmaceutical flower. He asks the question: is the flower an aid to the enhancement of human life, or is the human the reproductive organ of the flower? His answer: both. In this hybrid relation, Massumi indentifies the individual human maintains their health whilst the species of the flower is reproduced on a large scale rendering the human a reproductive organ of the flower. He concludes that this prosthesis is an *"asymmetrical prosthetic symbiosis"* benefiting the flower. (Massumi, 2002)

Second-order cybernetics recognises the observer as a critical part of her observations. This is an important step in furthering our understandings of techno-human relations as it gives a more honest picture of the study at hand. Further, cybernetic investigations officially came to include organic / inorganic hybrid systems. In light of contemporary philosophy and contemporary manifestations of technology, it becomes apparent that if observations lie between subject and object and if it is accepted that an object is its "being-perceiveds" and vice versa, then we find a state of reversible, prosthetic, assymetrical symbiosis. Conventional notions that prosthesis act for the sole benefit of the human initiating subject are surpassed by a *second-order prosthesis* where the non-human may be the primary beneficiary.

There is a connection between the study of cybernetics and the study of prosthesis: both are interested in communication and relationships between controller and controlled. Identifying the possibility of a non-human as a beneficiary of a techno-human relation is a shift from second order cybernetics into second order prosthesis, where prosthetics is defined as an off-shoot of cybernetics, particularly concerning techno-human hybrids[23] and building on an existing field of theory of techno-human relations involving extension, incorporation and need.

2. Corporeally based second-order prosthesis: Building on existing paradigms.

Prosthesis has its roots in the Greek *prosthetikos*, meaning "of the nature of addition, or giving additional power to." (Barhart, 2002) In general terms one thing is added to another for the sake of adjustment and augmentation. Engines, bodies, computers, cities, ecologies and societies all undergo these processes. Incisions are made, ordinary workings are redirected and finally the system is rewired to incorporate the new. Fitting with the theme of CAADRIA2011, prosthesis can be understood as a form of circuit bending, breaking and mending: the processes of adaptation between one thing and another, the merging of entities for enhanced functionality.

Conventionally prosthesis was used as a medical term to describe the replacement of a missing or dysfunctional human body part, however, the term is evolving. Over the last century the term has been used more widely to describe the human corporeal relation to its technological objects (Forty, 1990; Grosz, 2001; Vidler, 1992). Until more recently, this relationship was considered to benefit the human whilst being perceived as largely inconsequential to the non-human which, remained unstudied in illusory objectivity.

The current plethora of immersive and interactive artworks in galleries globally is testament to a growing consciousness (or sub-conscious) of second-order prosthesis. This section seeks to thoroughly analyse one such inorganic example of second-order prosthesis in relation to established theoretical paradigms on prosthesis within the existing literature on prosthesis. The *7 Meter Bar* was the artwork which, geminated many of the ideas expressed throughout this paper. The second-order prosthesis that is prominent in this example is corporeally based and is thus a good example to relate to existing, medically and architecturally founded literature. The artwork will be analysed under three key paradigms of prosthesis: incorporation, extension and need.

The *7 Meter Bar* installation was an immersive, mixed-reality public artwork / bar which operated in the Sydney CBD for the summer months of 2009 and was created by Richard Goodwin, Russell Lowe and Adrian McGreggor (Goodwin et al). The physical installation of the bar involved boats, cars, street furniture and other urban debris 'washed-up' into the under-croft of an undesirable and unimpressive Sydney building in an equally uninviting lane. There was a bench and area for bar staff to store and serve drinks, facilitating the operation of a profitable bar during the three-month installation. The 7m Bar involved the projection of its virtual double in which the weather was simulated and worsened as the real-life population of the bar increased. Changes in the bar population were detected via percentage changes in pixels viewed by a partially obscured camera. This input was fed into the Crysis Wars computer engine which, inserted and removed avatars within the virtual 7m bar, eventually producing catastrophic storms as the avatar population increased. The installation system existed in a prosthetic relationship with the bar population whose physical presence allowed the interactive sensory system to portray a simulated relationship between population and climate-change.

2.1. EXTENSION AND "THE LIMB OBJECT".

The first paradigm is of enhanced bodily functioning and bodily extension through the limbs. Resonating with its history in mathematics and medicine Le Corbusier regards the use of instruments as a sort of bodily extension, allowing the performance of various tasks with greater ease – the pen to write,

the chair to sit and the light to work at night. He describes such objects as *"objets-membres-humains"*. (human limb objects) (As described by Forty, 1990) Under this primary definition of prosthesis derived from Le Corbusier, the object of prosthesis extends the body, in a physically manifested, limb-like manner to increase functionality.

The instances of first-order prosthesis involving extension, especially regarding the assembly of the installation are multiple and not within the scope of this paper to discuss in detail. However, it is important to analyse the nature of the installation once assembled by the artists. It would appear that the artist has divided himself, allowed for an echo of his intention and capacities to be played out by a environmentally responsive system. Thus, the artist has created a secondary, "echoed" body of sorts, perceiving and responding to the world. The body's inorganic parts include the wiring, the projector, the wall upon which it is projected, the computer, the Crysis Wars gaming engine and the shipping container in which it is stored. These elements create an albeit simple, but functioning and responsive system.

There exist alongside these inorganic organs, a number of organic parts. For example, once the system was set up, the projector had to be locked away each night and reconnected every time the bar re-opened. This was performed by the bar staff. If such precautions were not undertaken, there was a high likelihood of the projector being stolen. Thus, this necessary practice ensured the continuing operation and "survival" of the immersive artwork. The staff might be considered protective prosthesis upon the operational system's functioning body parts. In the proliferation of immersive, mixed reality installation, it is possible to perceive the human as a reproductive organ this new type of body; human flesh, imagination and desire as the prosthetic of techno-proliferation. The reproductive physical extensions of the immersive system were the hands which assembled it.

This analysis of second-order prosthesis involves human action benefiting the technological system. It simply re-reads ordinary machine related actions in terms of benefit, protection and propagation. Massumi used the example of the organic, pharmaceutical flower, however, when we consider the human as a reproductive organ in second-order prosthesis of an inorganic machine, boundaries begin to blur: machines have "populations", "survival" and "reproduction": the lexicon of the technical and the biological overlap. The discourse at hand places the technological within the biological metaphor but the limit of the poetry as imaginative is questionable. The exploration suggests that in order to better understand second-order prosthetic relationships, the existing biological framework is a critical tool.[4] If these findings are to be taken up and investigated further, one must begin from within an expanded

field of ecology.

2.2. INCORPORATION: DEFINING NEW MODALITIES.

The second paradigm involves the incorporation of the prosthetic into the body's perceptual limits to establish an augmented and rewired functioning system, which is incorporated into the "body schema". Grosz (1990) discusses this phenomenon through Merleau-Ponty's hypothetical: if I have an itch…

> "I know exactly where it itches and am able, if I can reach it, to scratch without having to locate my hand in relation to the itch. This is true even if I use an instrument like a stick. From this point, Merleau-Ponty claims, the stick is no longer an object for me but has been absorbed or incorporated into my perceptual faculties or body parts."

Let us first look at the physical presence of the patrons within the bar installation. Their presence and absence allows the functioning body / gaming world construct to project its spectrum of possibilities. Patrons, passersby and staff enter into the field of the sensor and the percentage change in colour pixilation triggers virtual reality weather changes. The response to the population change is automatic and seemingly effortless, like using a stick to scratch an itch.

It is unimportant whether or not the patron is aware or willing to participate in this prosthesis. The patron may become aware of the connection and engage in a playful manner: moving groups of people into and out of the scope of sensory pick-up to affect the projected population and weather conditions. The initial digital prosthesis of the flesh means the absence of tactile techno-human relations: the "player" engages by moving / prostheticising her own body. In moving the body, the technology is adjusted. This is only possible because the patron's flesh is engaged in second-order prosthesis, incorporated and extending the functioning of the interactive system. The digital body thus incorporates all that enters its sensorial field, into its "bodily schema" via a loop of digital connection and response.

2.3. TECHNO-DESIRES: "THE PRETEXT OF LATENT NEEDS".

The final prosthetic paradigm is based on need. Adrian Forty (1990) writes:

> "prosthesis… implies that the body is incomplete – a point of view corroborated by psychoanalysis, where the body is experienced characteristically as a sense of loss or, as a lack."

Forty suggests prosthesis may go beyond physical and functional needs to address the socially constructed element of the body. A prosthetic can thus

augment the body on a social level in addition to enhancing the bodies functioning capacity. Driving an expensive car is one such example. Whether it be socially symbolic or a medical necessity, prostheses tend to address need.

In "Theses on Prosthesis: The Pretext of Latent Needs", Guillerme (1990) suggests that a fundamental characteristic of the organism is need. Whilst an insect might look to its ecosystem to satisfy its needs, the human is building up a techno-system of prosthetic possibilities. As such the human is continually regulating a set of socially and bodily associated needs through the prosthesis of an increasingly large number of technological objects. Whether it is abstract, social, medical or metaphoric, the prosthetic is drawn to the body via need.

In the *7 Meter Bar* the sensorial pick up of the bar population and of human activities, such as driving a car through the laneway or leaving a trolley in the sensory field of the installation all become the human resources for the system to undertake its designed function. In prosthesis of the second-order, flesh is a plug-in for the digital.

If the "thing" is its possible connections with other "things" then the interactive system is its potential connectivity to the human. It holds, as Forty explains that the body and in this case a technological, inorganic body, is defined by a sense of lack. That functioning body will thus do all that it can to engage the human in second-order prosthesis. The object has transcended the sum of its parts into a co-beneficiary in its relationship with the human. It is not only an enhanced functioning body that has incorporated human corporeality into its "body schema", augmenting its possible operations, but it is an evolving, reproducing species that by its ontological nature is defined by its implicit need for human connection.

Whilst the system might not daydream or yearn for such connection as a human might, need is not at all far from desire. As machines become more equipped in terms of their sensory functions and there is an increase in complexity and sophistication of output capacities, it is possible that these needs are met in more and more creative ways.[5] Desire might thus become increasingly evident as various evolving technological species become increasingly sophisticated in the way they resource their humanological needs in second-order prosthesis.

3. Imagination based second-order prosthesis: Human-aided design.

Ranulph Glanville uses a definition of design as an intelligent process of creating the new via a process of external feedback. The process is meandering and can be considered an out of control control system. Glanville uses the metaphor of wandering through the countryside and then suddenly realising

one has "arrived". (Glanville, 1994) He views computer-aided design (CAD) as falling short of its promises: it takes too long to compute changes, it cannot provide the space where ideas and strategies are formulated. In essence rather than inspiring further experimentation, it breeds certain conservatism. It may be argued, however, that programs such as Archicad compute changes and change drawings rapidly whilst others such as Maya provide dynamic rather than static design spaces as the background for ideas and strategies to come forth. (Lynn, 1999)

It is important to recognise CAD as a *medium* rather than a tool for design. Its processes and nature affect the thinking and design outcome (Glanville, 1992). It is a mechanism prostheticised by human imagination and intelligence to create variety and develop design details. By prosthetic reversablity however, the human body and imagination are the prosthesis of the program and machine. High demand of design programs and user feedback allow software developers to evolve software coding or software "DNA". Humans aid both "reproduction" and "evolution" to rapidly evolve the technological as species in asymmetrical, prosthetic symbiosis. As their tools and equipment evolve to become increasingly seductive to the designer, they actually draw in and attract the human resource of imagination and creativity. High demand from the designer guarantees the program / machine's reproduction and evolution. It is obvious but important to note, that without this demand, the programs would stagnate and never evolve, eventually ceasing to exist. Under second-order prosthesis, programs and machinery evolve via *human-aided design*.

Another level of human-aided design is at play. The machinery and its software are defined by its possible connections to the human but also connections and potentialities within its own virtual space. Virtual space and its manifestations are similarly imagination-initiated creations. Humans creating and communicating within virtual space of any sort: design based, gaming based or communications based, ultimately result in the survival, reproduction and evolution of these spaces. Imagination and curiosity may be seen as the human needs of virtual space. In an asymmetrical second-order prosthesis of symbiosis, the design out-puts, the Internet and gaming-engines also resource imagination and curiosity in producing human-aided design, constituting both design outputs and software / hardware evolutions. Thus, the conventional practices of computer-aided design in architecture and related disciplines could be just as validly conceived of as human-aided design.

4. Conclusions.

The technological object has its conventional role as a docile servant. However,

when preconceptions of objectivity are reconfigured so that perception lies relationally *between* "things", the previously understood nature of the "thing-itself" begins to falter. The ontology becomes concerned with the "thing's" (technology's) relational possibilities rather than impossibly isolated characteristics. As such, technology and human are co-defined, mutual prostheses, where technology may be the primary beneficiary in second-order prosthesis. Moving from an identification of the importance of the observer to the possibility of the technological as the primary beneficiary constitutes the viewpoint of second-order prosthesis.

In the *7 Meter Bar* case study, the human is read as a reproductive organ of the installation system. The lexicon and thinking continues along a biological line; we consider the "survival", "reproduction" and "populations" of interactive systems of a technological "species". Thus, in considering second-order prosthesis, boundaries between the biological and technological are traversed at an ideological level and the author calls for an expanded understanding of ecology in which to explore these relations, in particular the way in which the machine "needs" and "desires" human connections.

The final example looked at the second-order prosthesis of imagination. It conceived the design out-put as a specific need of CAD ensuring its survival, reproduction and evolution. Both the design outputs and the design of software / machinery constitute a second-order prosthesis of human aided design. At another level, virtual space including the Internet, Cartesian design space, gaming engines etc. are driven and exist via imagination. The creative products of these spaces have been brought about through second-order prosthesis of imagination in human-aided design.

A second-order view on prosthesis perceives technology in its capacity to benefit, proliferate and evolve and as such ideologically positions it within the scope of the biological. This shift seeks to realistically view the current proliferation of technological objects in terms of an expanded ecology; one in which humans are symbiotically and co-beneficially resourced by machines.

Endnotes.

1 In this way the connectivity defining potential function is perception: perception has a prosthetic nature.

2 Techno-human hybrids may involve both inorganic/organic combinations as well as organic/organic combinations. E.g. the case of the pharmaceutical flower.

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4 In an expanded field of ecology, the human is inevitably a resource to the technological. This situation could be viewed as symptomatic of 'enframing', Heidegger's prediction of the automated utilisation of human subjects for the momentum and purposes of tech-

nology's evolution. In this scenario, human corporality and later, imagination may be considered to be in 'standing reserve' for the technological system. Unfortuanately, it is not within the scope of this paper to draw an analysis of the implications of enframing within an expanded field of ecology.

5 See the work of Petra Gemeinboeck and her learning robots in her robotic installation, *Zwischenraume* 2010.

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References.

Barhart, R.K.: 2002, *Dictionary of Etymology,* Chambers Harrap Publishers, Edinburgh, 852

Foerster, H. von: 1972, *Perception of the Future and the Future of Perception*, Instructional Science Volume 1, Number 1, 31-43

Foerster, H. von: 1979, "Cybernetics of Cybernetics," in: Krippendorff k. (ed.) *Communication and Control,* Gordon and Breach, New York, 5-8

Forty, A.: 1990, "Industrial Design and Prosthesis" in *Ottagono*, Number: 96, September, 114-129

Glanville, R.: 1992, *CAD Abusing Computing,* eCADDe, Polytechnic University of Catalonia, Barcelona

Glanville, R.: 1994, *Variety in Design,* Systems Research, Volume 11, Number 3

Goodwin, R., Lowe, R., McGreggor, A.: 2009 "7 Meter Bar" an interactive artwork in *By George! Hidden Networks,* City of Sydney Public Art Initiative

Grosz, E.: 1994, "Lived Bodies: Phenomenology and the Flesh" in *Volatile Bodies: Toward a Corporeal Feminism*, Indiana University Press, Indiana, 86-115

Grosz, E.: 2001, "Lived Spatiality (The Spaces of Corporeal Desire)" in *Architecture from the Outside: Essays on Virtual and Real Space,* MIT Press, Massachusetts, 31-49

Guillerme, J.: 1990, "Thesis on Prosthesis: The Pretext of Latent Needs" in *Ottagono,* number: 96, September, 105-113

Heidegger, M.: 1977, "The Question Concerning Technology," in *The Question Concerning Technology and Other Essays* Harper Torchbooks, New York

Lynn, G.: 1999, *Animate Form,* Princeton Architectural Press, New York, 9-43

Massumi, B.: 2002 "The Evolutionary Alchemy of Reason" in *Parables for the Virtual: Movement, Affect, Sensation,* Duke University Press, London, 89-132

Vidler, A.: 1992, "Homes for Cyborgs: Domestic Prostheses from Salvador Dali to Diller and Scofidio," in *The Architectural Uncanny: Essays in the Modern Unhomely*, MIT Press: Massachusetts, 147-166

Weiner, N.: 1988, "Cybernetics in History" in *The Human Use of Human Beings: Cybernetics and Society"* Da Capo Press, Boston, 15-28