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An Aesthetics of Digital Virtual Environments

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ABSTRACT

This chapter examines digital virtual environments as a site for art and proposes a formal aesthetics for art in digital virtual environments. The study arises from the author's decades-long practice producing art in virtual environments and the related theoretical considerations that have arisen from that practice. The technical, conceptual and ontological status of virtual environments is examined in order to establish a base of intrinsic qualities that identify virtual environments as a medium for art. The philosophy of Gilbert Simondon is used to achieve this. The elements and principles the artist must employ to work with this medium are identified as data, display and modulation. The specificities of virtual environments as a medium for art are examined in order to establish a formal aesthetics. In particular, digital colour, visual opacity, digital sound, code, artificial intelligence, emergence and agency are identified as the primary qualities that the artist manipulates to bring forth art in a virtual environment.

INTRODUCTION: WHAT IS AESTHETICS IN DIGITAL VIRTUAL ENVIRONMENTS?

This chapter examines digital virtual environments as a site for art[1]. The study arises from the author's decades-long practice producing art in digital virtual environments and the related theoretical considerations that have arisen from that practice. The chapter attempts to theorise a genuine aesthetics of digital virtual environments, and in doing so, draws on aesthetics, philosophy, contemporary media theory and affect theory in an attempt to define an aesthetics for the complex arena of art in digital virtual environments.

To establish an aesthetics of art in digital virtual environments, first we must examine the technical, conceptual and ontological status of these environments in order to identify intrinsic qualities that might identify such environments as a medium for art. In other words, what can be done with this medium that cannot be done in any other, and how? This occupies the first section of the chapter, starting by identifying digital virtual environments as a *post-convergent* medium constituted by the elements of *data* and *display* and the principle of *modulation*. This is followed by an attempt to understand the consequences of this in terms, first proposed by the French philosopher Gilbert Simondon, of indeterminate *becoming*. The role of technical protocols, which are ostensibly highly determinist, are examined in the light of this indeterminacy. This is then brought to bear on the concept, much discussed in 21st Century media studies, of *autopoiesis*, to try to determine the status of digital entities in digital virtual environments. As well as Simondon, the thought of important contemporary scholars of media and culture is drawn upon, including Marshall McLuhan, Friedrich Kittler, Justin Clemens, Pierre Lévy, Gilles Deleuze, Claire Colebrook, Anna Munster, Felix Guattari, Rosi Braidotti, Luciana Parisi, Humberto Maturana and Francisco Varela.

Once this has been done, an aesthetics of digital virtual environments can be attempted, and this constitutes the second section of the chapter. Since digital virtual environments are a complex combination of many elements working together, it follows that an aesthetics will need to examine many different elements. First, the concept of *protocols* is revisited to examine the role of human and non-human agency in digital environments. This is achieved through programming code, which is identified as a major element of any aesthetics of digital virtual environments, and examined accordingly in relation to the Simondonian understanding, raised in the first section, of chains of modulation between data and display. This is followed by an examination of artificial intelligence and desire in relation to aesthetics, which leads to the important concept of performativity and its role in aesthetics of the digital, best articulated by art theorist Boris Groys. The role of time is then examined in relation to interactivity and digital networks, before a discussion of the role of colour and sound in the aesthetics of digital virtual environments. Besides Simondon and Groys, scholars and artists referenced in the second section include Luciano Floridi, Gregory Chaitin, Stephen Wolfram, Luciana Parisi, Bernard Stiegler, N. Katherine Hayles, Elizabeth Grosz, Colebrook, Manuel

DeLanda, Wendy Chun, Alain Badiou, Giorgio Agamben, Bill Viola, Quentin Meillassoux, Jon Roffe, Lewis Mumford, Yves Klein and Pierre Schaeffer.

Finally, as an appendix after the conclusion, I have included descriptions of some of the artworks I have had a hand in making in the past decade or so. These are placed in an appendix at the end of the chapter, as I would like the aesthetics I am trying to theorise in relation to digital virtual environments to stand alone, regardless of whether my own attempts at digital virtual art achieve any claim to aesthetic interest.

1. INTRINSIC QUALITIES OF ART IN DIGITAL VIRTUAL ENVIRONMENTS

The status of digital virtual environments as post-convergent sites for art

Digital virtual environments are *post-convergent*, that is, in McLuhan's sense (2001, p.10), containing all prior media as content (Nash, 2012). A post-convergent medium is the dynamic whole that is created by the convergence of all prior media, plus the excess that is both created by, and is required to create, such convergence.

Such post-convergent moves can perhaps be identified throughout the history of media, but the digital is distinguished by converging all previously differentiable media into an undifferentiable continuum, that of digital data (Kittler, 1999, p.2). Consequently, for media to be differentiated in the digital era, *digital data* must be *modulated* into some kind of sensible *display* state via protocols that virtually reassemble the required medium, be it a visible, audible or some other kind of sensible medium.

The digitisation process contributes its own operations to this process, creating an excess that cannot be rationalised exclusively in terms of a meta-media, because the concept of a meta-media is itself one of the media that is, or can be, explicitly virtualised as content within itself, just as the process confers a retroactive virtuality on all prior media being digitised as virtual content, creating both the prior media and the excess of their own virtuality.

Data, display and modulation as constitutive of digital virtual environments

The distinction between *data* and *display*, via *modulation*, is constitutive of the digital, and therefore of digital virtual environments - including realtime 3D environments such as those used in Massively Multiuser Online Role Playing Games (MMORPGs) like *World of Warcraft* or multi- and single-user world-building environments like *Second Life* or *Minecraft*.

The distinction requires an understanding of the excess that is not only created through the digital convergence but in fact constitutes our contemporary understanding of the *virtual*, when used in such terms as *virtual friend*, *virtual meeting* and *virtual reality*[2]. In this usage, the virtual is understood as a digitally networked environment which affects, and is affected by, the non-digital world (Lévy, 1998, p.30). Without conflating the two, it is possible to ascertain a relationship between this understanding of the term 'virtual' and Gilles Deleuze's nuanced philosophical concept of the same name (Nash, 2012). Colebrook's (2010) reading of Deleuze and Guattari's *desiring machines* is useful in this context (p.124), as is Anna Munster's (2006) notion of pulsing vectors, (p.90), both of which we will discuss a little later. Similarly, André Nusselder (2009) uses Deleuze, Peirce and Doel & Clarke to confirm an idea of the virtual that is "about actualization and not about realization (of possibilities)," in other words a virtual that is understood as different from the concept of potential and "expresses exactly this idea of a creation of new events." (p.37)

Gilbert Simondon and Digital Virtual Environments

Once we recognise the digital as being constituted in the bivalent relationship between states of data and display, we can understand the work of digital virtual art as that of *modulation* between these two states. The work of modulation is effected through selection of parameters, otherwise known as the use of protocols. This is where the unique qualities of artwork in virtual environments are revealed, with the careful selection and/or design of how data will be modulated from its generic, undifferentiated state into a display state. This is what might be called *facilitated ontogenesis*, that is to say, a conscious facilitating of what Simondon would call *transductions* in the *metastable* environment of digital data in order that a digital entity

individuates. Simondon borrowed these terms from physics, chemistry and biology, where *transduction* means the conversion of energy or information into another form, or, in Simondon's own words, "a physical, biological, mental, or social operation, through which an activity propagates from point to point within a domain, while grounding this propagation in the structuration of the domain." (Combes, 2013, p.8). *Metastable* refers to a system in a state of energetic equilibrium, where a tiny change in energy will break the equilibrium (Combes, 2013, p.5).

Simondon's philosophy is useful for understanding all sorts of phenomena in the physical and conceptual worlds, from geology to history, even though he is now primarily known as a philosopher of technology. But his philosophy is especially useful, if sometimes problematic, in the case of digital virtual environments, since it helps in thinking through the implications of the leveling or generifying operation of the digital (Clemens & Nash, 2010). This is because the traditional philosophical concepts of substantialism (ie, a unified being) and hylomorphism (ie, form given to matter) don't seem to apply to digital virtual environments at all. A generated digital entity in a realtime 3D digital virtual environment certainly cannot be said to be unto itself, since it doesn't exist except 'in' the virtual world, and nor can it be said to consist of matter given form, rather it is only form, and yet it can be sensibly perceived. Simondon's project from the beginning was to dispense with substantialism and hylomorphism altogether, along with their consequent subject/object dichotomy that Simondon felt made it impossible to think individuation, because it always privileged the individual as given. As he puts it in *The Position of the Problem of Ontogenesis* (2009a, p.5), it is better "to know the individual through individuation rather than individuation through the individual." The individual should be thought of as "a relative reality, a certain phase of being that supposes a preindividual reality, and that, even after individuation, does not exist on its own." (Simondon, 2009a, p.5). This ontogenetic viewpoint helps us to understand the nature of being of digital entities in digital virtual environments, since they are part of an ongoing process of modulation between states of data and display. Digital entities do not exist on their own, since they require a digital medium, and the "pre-individual reality" from which they emerge is that digital medium.

Protocols and indeterminacy

So everything, when digitised, becomes undifferentiated digital data and only when modulated into a display state can it be said to have any kind of differentiated existence. And yet, with protocols that govern such modulation, predictability can, but only to a certain extent, be relied upon to remodulate digital data into an expected display state. This "only to a certain extent", where indeterminacy is introduced through vagaries of modulation and display conditions, is quintessentially Simondonian as well, since he believed that indeterminate interactivity was part and parcel of the ontogenetic process (Iliadis, 2013, p.12). Indeed, this indeterminate interactivity is the hallmark of digital virtual environments of any kind. Think of a character moving through a realtime 3D game world driven by the arrow key on the player's keyboard. The sensible manifestation of this is a constantly changing arrangement of pixels on a screen, the constant change interactively prompted by constantly changing messages. The messages are the last modulation in a long chain of modulation sites from keyboard to graphics card, each exchange interactive and governed by specific protocols. The sensible display itself - the pixels - is a constantly changing arrangement of red, green and blue light emitting diodes in a two-dimensional matrix that does not constitute a character in a world, rather serve as yet another complex, interactive site of modulation between light, eye, mind and culture that eventually in some way individuate a character in a world. When seen in this way, the interactive indeterminacy is the only thing there is. This chain of indeterminate, interactive modulations is what constitutes the work of the artist in the digital era, and this is where we need to look to define an aesthetics.

Digital virtual environments and autopoiesis

In the digital era, many thinkers and practitioners have identified and attempted to work through this curiously plastic relationship between the individual and its milieu, and the concepts of *autopoiesis* and *allopoiesis*, promulgated by Maturana and Varela (1980) and extended by Guattari (1995), have recently gained traction as a potential method for doing so.[3] Anna Munster sees the distinction between technical systems as allopoietic (ie, broadly, producing something other than themselves) and organic systems as autopoietic (broadly, reproducing themselves) as erroneous. She does this by invoking Guattari's idea that technical systems form a machinic assemblage with humans, thereby becoming autopoietic (Munster, 2013, 8). This is a very interesting concept in relation to realtime 3D digital virtual environments or entities that

are, partially or wholly, driven by dynamic data sources. Such works, while conceptually available to previous eras (and even explicitly explored, particularly during the modernist era, where John Cage, Joe Jones and Yoko Ono perhaps stand as exemplars), are not really able to be enacted until the advent of the digital networked era.

These concerns are particularly relevant to digital virtual works that incorporate dynamic data in their unfolding - data such as the presence and actions of humans, or the dynamically changing data generated by some realtime data source. If we accept Munster's Guattarian notion of the autopoietic nature of the assemblage formed between human and technical systems, then we must attempt to establish what is being produced by such an assemblage in the case of such an artwork. Certainly, more data is being produced by the constant formation and reformation of this assemblage, and such data may be dynamically reincorporated as a data source itself. This may constitute a kind of technical self-consciousness, inasmuch as the audiovisual animation system may be said to be reproducing iterative versions of itself every moment. Does this sort of dynamic reproduction, or production, of a constantly shifting assemblage formed between animation and data source constitute an autopoiesis or an allopoiesis? Anna Munster's reading of Varela and Maturana's concept of autopoiesis offers the following definition:

> An autopoietic or living machine, a 'unity', maintains its composition relationally through interactions with its 'medium' or environment. Changes in the medium trigger changes in the unity that is the organized organism leading to adaptation.But, in the living unity, only those changes that conserve the organization of the living machine (that is, its autopoiesis) are 'structurally coupled' with it (Munster, 2013, p.6).

The similarities with the Simondonian view are clear here, indeed Braidotti (2013) directly equates a Guattarian notion of a machinic collective with the Simondonian metastable as a precondition for individuation (p.94)[4]. But how can we differentiate, in the case of a data-driven realtime 3D digital virtual environment, the medium or environment from the living machine, since it is not possible to separate the audiovisual display state of the environment from its state of data-as-data except in nostalgic McLuhanist or phenomenological terms that are quickly revealed as chimeric or, more accurately, as elements that may constitute elements of both or either of the autopoietic machine and its medium or environment?[5]

We could use Deleuze's Spinozan definition of a body[6] in an attempt to analyse realtime 3D data-driven digital virtual environments in Varela's (1992) terms of embodied cognitive structures interacting with encompassing contexts (p.334). Luciana Parisi (2004) notes that De Landa has done this to human-generated structures like markets (p.142). We might also identify, via the display state of the digital virtual assemblage, the characteristics of an autocatalytic or semi-closed circuit that generates its own stable state and evolves through drift (Parisi, 2004, p.142). But even if we do these things, it is still not clear where the thresholds are between the technical system and its medium, and even less clear whether it is producing something different from itself, reproducing itself, or producing some hybrid. This is where Simondon’s philosophy may be useful, since it obviates the need for any definitive location of the individual, rather concentrating on the ongoing chain of transductive operations that keep the entire assemblage in a constant state of becoming. This is a concept that, while it may be difficult to understand in terms of our own subjective experience of the world, is easier to understand in the context of digital virtual operations.

With this, the status of digital virtual environments as sites for art, and therefore their associated aesthetics, are revealed to be related less to their audiovisual (or other sensible) display than to the chains of modulation that represent the becoming of digital virtual environments, and of which human-sensible display is but one aspect.

2. AN AESTHETICS OF DIGITAL VIRTUAL ENVIRONMENTS

The selection and/or design of modulation protocols is the primary work in the art of digital virtual environments, so this is where an aesthetics that is intrinsic to digital virtual environments will reside.

Protocol as interface and vice versa

It is important to remember, as Luciano Floridi (2014, p.35) points out, that *interface* is simply another word for protocol, even if it has informally gathered the special meaning of a protocol that governs modulation between a human user and a digital device (eg, a software menu or a hardware controller), but we can equally talk of interfaces between digital entities or protocols between humans and digital entities. Of course the word 'protocol' itself was originally applied to interactions between people - people from different places.

Aesthetics, protocols and digital ontogenesis

An aesthetics of digital virtual art will take into account protocols that facilitate *digital ontogenesis,* [7] which often displays as digital adaptation and digital behaviour (commonly called *artificial intelligence* and/or *artificial evolution*), emergence and digital agency. Programming code is the primary interface available to anybody working with these phenomena, so code is of primary interest to an aesthetics of digital virtual environments. There is not the space here to go into the differences between so-called hand-coding, visual coding and graphical user interfaces, which are themselves different levels of interface. In this chapter they will be conflated, but of course the same principles of modulation apply to these interfaces as to all digital work.[8]

Programming code and digital agency

Programming code[9] is the primary means by which artists can help bring forth the qualities of artificial intelligence and digital agency. This is because both of these qualities emerge from the milieu of the virtual environment when appropriately seeded by programmed code that creates parameters, via which the modulation from data to display is effected in a Simondonian chain of bivalent relationships. This might be termed *artistic coding*, but in a different sense to the concept of elegance in code (Floridi, 2011, p.318; Chaitin, 1998, p.29), algorithmic complexity (Wolfram, 2002, p.1143) or "computational beauty" (Parisi, 2013, p.66). Rather, it is coding that interacts with the modulation chain because, as Simondon says,

> The true principle of individuation is mediation, generally supposing an original duality of orders of magnitude and the initial absence of interactive communication between them, followed by communication between orders of magnitude and stabilization (2009, p.7).

Code is not digital

Code itself is not digital. Code is a kind of writing. But it is different from the Platonic hypomnesic sense of exteriorised memory[10]. This is because code is a working out that requires inscription, as when physicist Richard Feynman, as quoted by Hayles (2012), insists that the marks he makes on the paper are the actual work, rather than a transcription of something that has already happened in his head (p.93). We may find a way from this to the Simondonian concept of individuation, because code is a method of human writing that allows the writer to interface with the metastable pre-individual real that constitutes unmodulated digital data. The code is an interface to a process of individuating digital entities via "proximal forces in tension" (Grosz, 2012, p.45), or what Anna Munster (2006) would call "vectors that pulse through the directions and contours of matter" (p.90). As Grosz (2012) puts it, this pre-individual real "is marked by singularities, specificities, particular forces, specific locations, singular potentialities. It is the order of pure difference" (p.45).

Code is a human interface to the assemblage that allows these specificities, this process of individuation, to emerge. Grosz (2012) says that this occurs "not through logic, but through the creation of a mode of interaction, a form of communication" (p.46). The entire assemblage of code, digital data and display is an example of this mode of interaction, and code is the non-digital interface to that assemblage, conceived of by humans through the externally-facing form of thought that we do in fact think of as logic. So, the digital might be new, but code is not. Of course, the so-called digital philosophers suggest that digital is not new, rather discovered (Fredkin, 2003, p.189). But one need not accept their solipsistic, totalising ontological philosophy to accept that we interact with digital data in order to actively participate in the synergetic inscription relationship between matter and information . To quote Grosz (2012) once more, "matter and information cannot be understood as separable (unlike in cybernetic models), but where each order marks the other and is in turn enhanced by it" (p.46).

Code and indeterminacy

When coding, a person is talking *with* a machine, but it is a soft machine, one link in the long chain of modulations, they are not talking directly *to* the hardware, even when coding Assembly, just as when writing with pen on paper a person is not directly addressing the physical and chemical bonding of ink and paper, rather they are engaging interactively with the chain of interactive modulations that constitute physical chemistry. In this sense, machine to machine communication (a current buzzphrase amongst digital capitalists and some media theorists) has always been an integral part of not only digital computing but the very process of individuation itself, and Simondon (2012) recognizes this in his two postulates of "technical mentality" (pp.3-4)[11].

When seen in this way, code moves from being a deterministic engine in the teleology of a pre-given individual, to being a force in an evolving assemblage of affective bodies that appear in relations and modulate those relations, thereby constituting the individual (ie, in this case, the software), while always bearing the pre-individual, as Simondon (1993) says, "to such an extent that the finally constituted individual carries within it a certain inheritance associated with its pre-indivdual reality" (p.306). The coding assemblage literally enacts this ability to always become a different individual, as prosaically seen in versions, upgrades and patches, and more generally in the practice of object oriented programming, which is an exact enactment of Simondon's (2012) first postulate of technical mentality, that "the subsets are relatively detachable from the whole of which they are a part" (p.3).

Aesthetics as an understanding of modulation chains

An aesthetics of the digital virtual will understand this postulate at all levels within a digital virtual environment populated with generated and/or self-generating digital entities. Simondon (2009) talks of "internal resonance" as a defining difference between the physical (ie, the non-living; for example, a crystal or a star) and the living, where the "living individual is a system of individuation, an individuating system and a system individuating itself", whereas the physical is "perpetually peripheral to itself, active at the limit of its domain" (p.7).

Artificial intelligence and digital entities

Artificial intelligence, ie, digital behaviour and adaptation, is linked with the concept of a digital entity, that is, any (virtual) object that exists within a virtual environment. Such an object may have been explicitly instantiated (ie, modulated into virtual existence) by the interaction of a person, for example by code or in response to some other human interaction such as a keyboard stroke or via a motion sensor, or it may have been instantiated by another digital entity. This other digital entity may exist in the same virtual environment or another, such as is the case with environments that are generated by an external data source, and may itself have been instantiated by another digital entity and so on.

Does the concept of digital entities encounter a similar problem to the boundary problem encountered above in relation to autopoiesis? Can a digital entity be said to possess an internal resonance because it does contain within itself the code to individuate another digital entity, or is it like a (digital) physical object that individuates only at its limit, without a "veritable interiority?" (Simondon, 2009, p.7). Grosz (2012) confirms Simondon's anti-vitalist position when she says that, for him, "[l]ife is not a special kind of substance, a vital force" (p.46), so we need not be concerned with a judgmental binary concerning life, and instead concentrate on the fact that digital entities "share the same pre-individual resources" (p.46) as living or physical entities. If the "vital is an order of elaboration of the physical, which is itself the expression of ... pre-individual tensions" (p.46), then there is no reason not to think the same of the digital.

This may be what Colebrook (2010) means when she talks of a "sense beyond the actual" (p.127), and when she says,

> It is naive and uncritical to see the analogue as a pure and continuous feeling or bodily proximity that is then submitted to the quantification of the digital, a digital that will always be an imposition on organic and vital life. There is, however, an inorganic mode of the analogue that is not a return to a

> quality before its digital quantification, but a move from digital quantities or actual units to pure quantities, quantities that are not quantities of this or that substance so much as intensive forces that enter into differential relations to produce fields or spaces that can then be articulated into digits (2010, p.124).

In saying this, Colebrook is drawing on Deleuze & Guattari's concept of desiring machines, but she is also bringing to light a relationship between Simondon and Manuel DeLanda, (1993) who talks of nonorganic life (p.126) and phase transitions (2002, p.123). In Simondon, a technical being emerges (ie, individuates) upon a kind of phase transition when separate elements unify in action with inputs and outputs (ie, bivalent openings of modulation) at the micro-, macro- and meta-levels.

Code, writing and desire

Colebrook's evocation of desiring machines is a different kind of desire to what Hayles (2012) talks about when she cites Tanya Clement as characterising the ostensible unforgiving exactness of code as the "exteriorisation of desire" (p.42). The relationship of this idea to the Platonic concept of hypomnesis, mentioned earlier, is clear, but it is unclear how this is unique to code and not simply a function of the exteriorising imperative of language itself. Hayles (2012) never explains why, as she puts it, "[n]eeding to translate desire into the explicitness of unforgiving code allows implications ... that may not happen with print" (p.42), or how "the requirement to write executable code means that every command must be explicitly stated in the proper form" (p.42) is different from writing a letter, ordering a pizza or having a conversation with another human being. Further, Hayles (2012) conflates what she calls "an abstract computational model" (p.42) with code itself and excludes both from a capability for noise, ambiguity and complexity, seemingly ignoring Simondon's two postulates of technical mentality, which Hayles otherwise thinks of positively. At the same time, though, Hayles (2012) does recognise, via Kittler, the generifying effect of the digital in relation to human-facing text (p.42), and that a new form of text- based endeavour that interacts with a Simondonian individuation via the digital arises as a result (p.41), but Hayles does seem to persistently conflate code with the digital, which is a subtle but important mistake.

Chun (2011) eloquently points out the error of this conflation, and illustrates the Simondonian assemblage of synergetic modulations of which code is the human interface, when she notes that "[t]he relationship between executable and higher-level code is not that of mathematical identity but rather logical equivalence, which can involve a leap of faith" (p.24). She goes on to show that the belief that instructions flow pure and unsullied from code to execution with no intervening alterations or behaviours unintended by humans is a mistaken belief that strongly informs an ideology of computing. This would be in contrast to a Simondonian assemblage of synergetic modulation chains. As Chun (2011) puts it, "Code ... has always been regenerative and interactive; every iteration alters its meaning" (p.25).

Aesthetics, protocols and modulation

This of course is not news to those working with the iterative design cycle, so the question for artists, and for aesthetics, is how to do that? The answer is in the use and design of protocols. Protocols facilitate modulation. Like code, protocols are not intrinsically digital, in that we have always had protocols as a crucial enabler of communication. Protocols are a kind of code, both in the social communicative sense, and in the sense that they must be coded into any entity that intends to make use of them. In relation to code, the protocol is a formalisation of the decisions as to how to modulate data. The coding and use of protocols encapsulates the entire modulation process, and therefore is of primary interest to an aesthetics of digital virtual environments.

Nearly all protocols we avail ourselves of when working with networked digital data have been predetermined and operate in the realm that might be characterized as below consciousness. Some of these of course are based on interface metaphors from the pre-digital era, such as, when using a text editor or word processor, physically pressing the 'w' key will display a lower case 'w' on the screen, and these so-called intuitive metaphors (because they directly model behaviors that have been learned previously) usually go unquestioned until a different modulation parameter is enacted, like when the 'w' key means to move a player avatar forward in a realtime 3d virtual environment, or when it means to save a file in vi's command mode.[12] These may seem trivial examples, but they are interesting because they both have 'creation myths', of various

contestability, around why these modulations were chosen (for vi, 'w' stands for 'write', and for the walking avatar, it supposedly either represents 'w' for 'walk' or the pragmatic decision of the right-handed programmer/designer John Carmack when creating *Doom*), and they are good illustrations of both the arbitrariness and generational transmissibility of these decisions-as-tropes.

Such examples operate at a fairly macro level, but decisions as to how to modulate occur throughout all levels and processes of digital computing, to the extent that they can be said to constitute it. At every step along the way, or link in the chain as Simondon might put it - highlighting the bivalent, synergetic nature of these sites of modulation - decisions must be made as to what parameters will be used for modulation and how they will be enacted. This is true at both micro- and macro-scales, for example where a bit will be written; how data will be visually represented in an infographic; how the state of a Boolean switch will be enacted by a digital entity; how a person's social context will be displayed on a social network website. This is where a primary aspect of an aesthetic of digital virtual environments lays. Often, as Kitchin and Dodge (2011) discuss in relation to control systems, these protocol decisions are presented as natural or intuitive or pre-given or inexorable. An aesthetics of digital virtual environments is very sensitive to such elisions and conflations regarding the decision making around protocol parameters.

Visualisation and pre-convergent attitude

In particular, an aesthetics of digital virtual environments is not interested in work that simply visualises either the process itself or some data source in a teleological or deterministic manner without surrendering to the interactive indeterminacy of the modulation chain. Such a teleological visualisation is simply engaging a pre-convergent attitude that perpetuates the dominance of romantic formalism (Badiou, 2006, p.133), and contributes nothing to a new understanding of a digital society. As Alain Badiou (2006) says in his *Manifesto of Affirmationist Art*, "it is better to do nothing than to work formally toward making visible what the West declares to exist" (p.148)[13].

Modulation as performance

Boris Groys (2008, p.85) intuits this, as a consequence of the fundamental generifying operation of the digital, when he says that the digitising of images turns the visual arts into performing arts. By saying "every performance is an interpretation and every interpretation is a betrayal, a misuse" (Groys, 2008, p.85), he is identifying the entire modulatory assemblage of the digital as performative, which is a useful way of understanding the historical vacuum that is ostensibly created by the convergence of all differentiable media that renders meaningless such distinctions as visual art or text. The performance paradigm provides a method of engaging positively and non-teleologically with the indeterminate nature of the interactions in a modulation chain, because a performance is intrinsically indeterminate *in its process*. Every moment of a performance represents a site of modulation - how will the performer interpret this moment, influenced by the previous moment, anticipating the next by creating it? This performance paradigm raises concept that is crucial to an intrinsic aesthetics of digital virtual environments: *time*.

Interactivity and time

To state the obvious, this is because digital virtual environments are interactive, that is, they are able to be intervened in by a person in real time (ie, 'on the fly')[14] (Nusselder, 2009, p.36). This apparently simple point is a distinguishing quality of digital virtual environments, not because the user is interacting with the artwork, which has been a pre-digital element of art since at least Yoko Ono's *Cut Piece* in 1964 (Stiles, 1998, p.278),[15] but because the user is engaging with the modulation process itself, which is already indeterminate and interactive. In this sense, the interactivity is defined by the generifying of both the user and the artist into another bivalent site of modulation, not less important or determinant than any other site, and not more.

Initially, the implications for time would seem to be obvious; interactivity takes time. But this is not unique to interactivity, all art forms take time, most obviously music and video or cinema, but even still images, which Agamben (2013) says "have actually charged themselves with time" (p.4). He also quotes Bill Viola as saying that "the essence of the visual medium is time" (Agamben, 2013, p.5). Simondon's philosophy would reconfigure this concept to say that interactivity *makes time*. This is an oversimplification, but it

serves to introduce Simondon's concept that time occupies no special ontological position in becoming. More specifically, time emerges "from the pre-individual, just like the other dimensions that determine individuation" (Simondon, 1993, p.315). This would be a conception of time similar to Quentin Meillassoux's (2008, p.101), and therefore invites consideration of the tension between a conception of time as an ordinary dimension, and both the engineering concept of time, for example as illustrated by Chun (2011), "signals propagate *in* time over space" (p.26, emphasis added); and the physicist's concept of time, i.e,, "that time exists because the vacuum speed of light is constant", or in the jargon "time arises when a 4-dimensional real smooth manifold is endowed with a 1-foliation, that is, with a nowhere vanishing smooth vector-field" (Chaitin et al, 2012, p.122). In other words, that time is ground (Roffe, 2012, pp.63-64). We might characterise this tension as the difference between the arrow of time and the undulating iterative cycles of rhythm, where in fact the former is but a strictly quantised version of the latter.

Contingent time

Understanding time as an interactive product of modulation chains helps us understand how time can be both strict and undulating at the same time and in many different modes. Lewis Mumford (1963) recognised that the strict regimenting of rhythm allowed industrial-era captialists to instrumentalise power, not because of technics, but with technics, formalising time as power (pp.196-199). Adrian Mackenzie (2002) uses a Simondonian approach to show that such regimented time has, in the interest of power, come to be understood as autonomous, but in fact is "purely neither social nor technical," rather it emerges from "an articulation of diverse realities" (p.98).

Digital networks have brought this contingent, non-autonomous, nature of time into stark relief both technically and socially. Technically, the phenomenon of lag in realtime interactive environments forces us to rethink our acceptance of time as an autonomous authority regulating being. Lag is the delay between, for example, a key being pushed and the result of that keystroke appearing in the virtual environment.[16] Socially, the global access of the network highlights the diverse subjectification to timezones of people who are not co-present, such timezones being nominally based on the movement of the earth in relation to the sun, but in fact emerging from a complex chain of modulations between planetary movement, people and technics (Mumford, 1963, p.201).

Time and power

An aesthetics of digital virtual art must be sensitive to these considerations of time. Since the digital generifies everything, it is important to recognise that political, ethical and social values then become protocols in play in the modulation chain. Simondon and Mumford both recognised this (Simondon, 1992, p.306-310; 2010, p.229~; Mumford, 1963, p.60-106). Digital capitalists like Facebook and Google also recognise this, indeed it could be said to constitute their philosophy. In other words, the digital can be used to enact libertarian capitalist values (Schmidt and Cohen, 2013) just as readily as it can be used to invite participation in a caring and diverse egalitarian social ethics (Braidotti, 2014). Those who understand this in the contemporary era have a power advantage over those who don't, and this partially explains the success of Facebook or Instagram, which are cynically marketed as self-empowering expressions of the digital, when in fact they represent the most anachronistic pre-convergent circumscribing of a universal machine into a single-use machine. All contemporary 'social media', a term that instantly identifies itself as a rear-view-mirror retrofit, recognise time as power, relying as they do on users *spending time* working to produce content for them with no recompense other than a vaguely defined 'status' or 'reputation', as well as spending time consuming that content, with time measured and tracked by clicks, 'likes' and views. An individual's time becomes just another set of generic digital data, able to be modulated through any kind of ideological protocol. In the case of contemporary digital capitalism, the protocol tends to modulate into a deceptive display constructed around a false sense of self-empowerment and individualism hiding an exploitative manipulation of the generifying operation of digital data in the service of massive profit. As Agamben (2013) says, "the real paradigm of life in the modern era is not movement but time" (p.4).

Digital virtual environments and relational aesthetics

Because the big digital capitalist network apps (ie, 'social media') exploit the model of a static individual while realising the app using Simondonian concepts of dynamic individuation, the entire contemporary

social networking model represents an impoverished hijacking of Bourriaud's (2002) relational aesthetics, by exploiting "intersubjective encounters ... in which meaning is elaborated collectively" (Bishop, 2004, p.54). Alarmingly, in a stark illustration of the eminently plastic and generic nature of digital data, social media apps do this by converting "the realm of human interactions and its social context" (Bourriaud, 2002, p.5) into the individual "space of private consumption" (Bourriaud, 2002, p.6). The ability to do this relies on the plastic status of time in digital networks, enabling the exploitation of time as power.

The would-have-happened

The plastic and non-autonomous nature of time is further illustrated by the weird phenomenon of the *would-have-happened* that can be encountered when so-called 'artificial life' or 'artificial evolution' is enacted in multi-user digital virtual environments. This is where a user may initiate a sequence of, say, artificial evolution [17] and then log out before the sequence has played itself out. If no other user logs in to or visits that particular section of the multi-user digital virtual environment[18], and then the original user logs back in again some time after the artificial life sequence has finished, the user will encounter the curious state of something that *never happened* presenting literally *as if it had happened*. An instrumentalist rationalisation might object that the system simply ran through the calculations-that-would-have-happened in the instant that the user logged back in again. Even this explanation relies on an utterly plastic and non-authoritative model of time, nominally taking its reference from CPU (Central Processing Unit) cycles, and ultimately is unviable due to the complex set of indeterminate modulatory interactions required to maintain the digital audiovisual illusion of a digital virtual world that is subject to a version of the authoritative time that runs the psychosocial world of human beings.

An aesthetics of digital virtual environments would attend very seriously to all of these considerations of time.

Virtually retroactivated pre-convergent aesthetics

It should be clear by now that digital virtual environments can not be considered a primarily visual medium, even though they are often treated as such, in a McLuhanistic rear view mirror operation. If anything, the closest precedent artists have for operating within digital virtual environments would be musical practice, particularly of the latter half of the 20th Century, but it would also be a mistake to consider sound, or any discrete sensible phenomenon or practice, as the primary characteristic of digital virtual environments. The temptation to define such characteristics arises from pre-digital notions of media and art, with such descriptors as 'visual art', 'sound art', 'video art' and so forth. In fact, as W.J.T. Mitchell (2005, p.257) shows, it has never really been possible to consider any art or media form as restricted to one sense. This understanding itself is converged and virtualised as content in the post-convergent digital era.

At the same time, since digital virtual environments are a post-convergent medium, it follows that all prior concepts of aesthetics, ie, those concerned with audiovisual display, are contained within it. More precisely, these aesthetic considerations, or elements, are digitally converged within the environment, and the retroactive virtuality that is thus activated contributes to the excess that comprises: the pre-converged sense of the element; its post-converged sense (where it recognises itself as content of itself); and all the digital operations - ie, modulations - required to achieve this state. The two most prominent of these elements, in terms of display, are colour and sound.

Digital virtual colour

The great modernist explorer of colour, Yves Klein, could have been intuiting the digital when he said in 1959, "the painter of the future will be a colorist of a kind never seen before, and that will occur in the next generation. And without doubt it is through color that I have little by little become acquainted with the Immaterial" (Klein, 1992, p.804).

Mumford, in his 1934 work *Technics and Civilization* (1963) talks of an "esthetic compensation" of colour in art for the incursion of technology into the physical environment of people, where "instead of the harsh realities one encountered under the sun, there was a veil of tender lavenders, grays, pearly yellows, wistful

blues." (p.199). This is an example of the modulatory nature of art mediating between previously disparate realms, of the environmental effects of technology on the physical and the psychosocial, by the use of colour.

The crucial consideration for an aesthetics of digital virtual environments is that colour is but one more generic element in the modulation process from data-as-data to data-as-display, rather than an element that has a pre-given materiality that defines what operations can be performed with it, and therefore *any data* may be displayed as colour. This is the crucial point that is missed by Lev Manovich (2001, p.300) who, even while attempting to understand the loss of indexical relationship between digital and physical reality, doesn't understand that an image that has been digitised is *no longer an image*. This crucial point is also missed by colour historian and Manovich critic Richard Misek (2010) who, while acknowledging the dematerialised nature of digital colour, adopts a positivist tone to conflate a protocol, i.e., "24-bit color space" (p.165), with a pre-given indexical materialism.

Digital colour *is* displayed via digitally interfaced light emitting devices which ostensibly conform to an emissive mode of colour known as the additive model of red, green and blue, and these elements *are* discretely accessible from within the protocol via code, and indeed yield the unique ability to manipulate transparency and opacity of displayed colours to a fine degree, but this is in no way a materially pre-given relationship. Further showing the absolutely arbitrariness and absolute privilege of protocols in digital virtual environments, even though the colour mixing model in digital space is usually displayed as additive, once a colour is chosen and 'applied' in the digital virtual environment, it will conform to a *subtractive* model of colour mixing. An aesthetics of digital virtual environments would understand, as foundational, that up until the moment of its display, digital colour does not constitute anything that can in any way be thought of as a colour; it is a set of digital data that if modulated according to certain protocols will display in the world as coloured light.[19]

Once such a display has occurred, the pre-convergent aesthetics and qualities of colour can of course come into play. These aesthetics and qualities have been the subject of speculation among some of history's greatest thinkers and artists since ancient times[20] and appeared to be no closer to yielding to any unified philosophical, psychological and physical system of knowledge even before the virtualising operations of the digital convergence recursively complicated an already extremely complicated field (Crone, 1999, p.233). This is apparently because colour is a "human sense" rather than a material phenomenon in the world, and is *time-dependent*.[21] (Hanson, 2012, p.3). In this way, we might call colour the music of the eyes.

Digital virtual sound

Once again, the crucial point about sound in digital virtual environments is that, due to its generic ontological status as digital data, any data may be displayed as sound. Once modulated into an audible display state, virtual sound objects may be manipulated in a manner identical with virtual visual objects, or any other kind of virtual object. It is here that it becomes clear just how different the work of art in virtual environments is from previous artforms, even though all previous artforms may be virtualised and emulated within virtual environments.

Given the general historical lack of indexical tendencies in the history of music and sound art, this pre-convergent history may provide some clues as to an appropriate aesthetics of digital virtual environments. It is possible to see a relationship between the radically generifying digital and Pierre Schaeffer's (2009, p.76-79) concept of "sonorous objects" in an "acousmatic" situation. This is the condition of sound dissociated from its material cause through technological means, and its associated listening state. Ignoring for the moment Schaeffer's (2009) modernist, potentially technodeterministic overtones, his "acousmatic procedure" understands "the most general musical situation," where the listener forgets "every reference to instrumental causes" and devotes themselves to "entirely and exclusively to *listening*" (p.81, emphasis in original).

Where an aesthetics of digital virtual environments diverges from Schaeffer (2009) is when his acousmatic approach denies "cultural conditioning" (p.81). For Schaeffer, this was to remove the listening experience from what he saw as the overdetermined concept of music, so that sounds that had previously been excluded from a cultural definition of music could now occupy an equal place alongside more culturally conventional sounds produced by musical instruments. This interesting operation on an already abstract and non-indexical

artform can retrospectively be seen in Simondonian terms as an individuation that mediates two previously disparate fields ('music' and 'sound' or 'noise'), thereby bringing forth a new associated milieu where Schaeffer's concern to remove cultural conditioning is understandable in his context. An aesthetics of digital virtual environments, on the other hand, must always primarily bear in mind the psychosocial and cultural conditions and associated ideologies that have informed the development of protocols. As Jacques Attali says in his 1977 work *Noise: The Political Economy of Music*, "any theory of power today must include a theory of the localization of noise and its endowment of form." We can reconfigure this assertion to say that any theory of power today must include a theory and aesthetics of the radical generifiying operation of the digital and the protocols that are employed to remodulate digital data into display.

As with colour, and every other pre-convergent extant element, the sheer scope of possibility that is offered to the sound artist or musician confronted with digital virtual environments can sometimes cause a reactionary impulse to reconstrain the liberated concept of sound (as radically dematerialised sonorous object without origin) based on weak interface metaphors from the physical world. As noted above, since music can be seen as already non-indexical, it can sometimes be difficult to appreciate the implications of the generifying operation of the digital, specifically in relation to the difference between a recorded sound and a synthesised sound, a difference that literally has no meaning within a digital virtual environment, an environment that is capable, to speak in pre-convergent terms in order to illustrate the absurdity of same, of simultaneously synthesising and recording a sound at the same time, or recording a sound *before* it has been synthesised, or replaying a sound that *would have been* synthesised had somebody been present to listen to it. The inadequacy of Schaeffer's phenomenological approach is clearly revealed in these examples, and it becomes obvious that an aesthetics of digital virtual environments will stay attendant to the modulations that result in sonic display and their interplay with all other modulations and display states. All digital data is generically equivalent and therefore may be modulated in the same manner, so that a 'sound' can be 'animated', and not only in pre-convergent terms of animating parameter changes over time, but the 'sound' itself may be animated in 'space', since neither the sound nor the space can be said to exist in any other terms than as digital data modulated into a display state. The very strong temptation to index digital virtual environments to physical space must be resisted at all times, otherwise we end up with nonsensical, reactionary metaphors like a 360 degree speaker moving through space of its own volition with no energy source. Since such a thing is impossible in physical space, an attempt to metaphorise such a thing in a digital virtual environment can lead only to weak romantic formalism that represents a surrender of power to digital capitalism.

CONCLUSION

An aesthetics of digital virtual environments must closely attend to the conflations and elisions offered by metaphors that attempt to index digital virtual environments to physical space, recognising the romantic formalist impulses that drive this and therefore serve only, in Badiou's (2006) terms, to reinforce the power of global digital capitalism dedicated to the enslavement of all people in a global sweatshop of metaphor-based identity production. How is it possible for art to engage with the digital networks and subjects of digital capitalism without reinforcing and promoting the values and practices of digital capitalism?[22] The answer lies in the concept of realtime performance, and the work of digital virtual art becomes parameter selection; selecting the parameters for modulation from digital data into display is the work of digital virtual art. Digital capitalist networks choose parameters that ensure a smooth time, an eternal present with no reference to past or future, in order that repetition can be presented, and consumed, as innovation. Digital virtual artworks must, therefore, be constructed using parameters that are aware of time as differentiator. Since time is the medium in the performance of the digital, self-assembling digitally networked artworks must incorporate, and present means towards, time in its role as the constructor of difference. Time on networks, distributed and un-arrow-like, becomes a material in the construction of resistance against the entirely smoothing impulses of digital capitalism, which not merely brooks no resistance, but is incapable of understanding resistance, since its libertarian vision is to absorb everyone and everything into a smooth continuum of consumption in the eternal present, where differences in cultural nuance and time are simply problems to be overcome (Schmidt and Cohen, 2013, p.19).

Digital virtual artists must select parameters that ensure modulations that draw attention to the underlying technologies and networks being used, that lay bare the crushing solipsism of predictive filters, that invite people to consider their position as slave-producer-consumers for a handful of giant libertarian capitalists

and recombine the same tools into an individual production machine that teases apart and frays the all-too-shiny web of filaments that bond us in our narcissistic stupor. Again, this is a difficult task when the very networks of bondage are presenting themselves as the empowering liberators. But Groys (2008) is right to insist that the “logic of equal aesthetic rights” (p.16) actually results in an autonomy of art that has a positive, affirmative imperative as its contextual specificity transcends the smooth parade of digital capitalism’s right-now.

APPENDIX: SELECTED ARTWORKS BY THE AUTHOR

The above are some of the questions that I have been attending to in the past few years via my work in realtime 3D audiovisual interactive animation. *Ways To Wave* was a collaboration between John McCormick and myself, presented at the 01 SJ Festival at the San Jose Museum of Art in 2008). The work comprised an assemblage formed between a physical controller installed in the museum and an audiovisual volumetric sculpture in the commercial realtime 3D multiuser environment called Second Life. The physical controller is constructed of colored etched perspex, in a lotus-like arrangement of 3 concentric circles of 8 petals, which can be played with by users. The position, angle and velocity of the petals each controls a different parameter of the virtual artwork, such as size, color, sound volume, and speed. None of these parameters were fixed in any linear sense, as is usually the case with hardware controllers for virtual environments, such as a joystick's position predictably dictating the speed of a player character, rather the parameters and their resulting animations were dynamically generated through the playing of the work itself, which could be effected either by physically visiting the gallery or virtually logging in to the art work. This facilitated a collaboration across non-linear temporal space, dynamically reconfiguring physical and virtual space, visual and aural media, in a symbiotic lattice of experience. In technical terms it is unclear whether such an assemblage may be considered autopoeitic or allopoeitic. More accurately, it seems possible, using various readings of Varela's theory as discussed above, to convincingly argue for both or either. Perhaps Varela's concepts, then, really are only useful when applied to the biological world and are unable, like media, to differentiate themselves in the digital without applying arbitrarily restrictive boundaries or thresholds in the manner of Mcluhan's rear view mirror (Mcluhan and Fiore, 2001, p.75).

Babelswarm was a collaboration between myself, Christopher Dodds and Justin Clemens. It was the result of the inaugural Australia Council Multi-User Virtual Environment Artist-in-Residence program. It was staged physically in the Lismore Regional Gallery, NSW, Australia and in the realtime 3D multi-user virtual environment Second Life. Activated by the voices of visitors in the real world gallery and chat messaging from virtual visitors in Second Life, a swarm of letter cubes- programmed to seek out their original word position- slowly builds a morphing, virtual Tower of Babel. This tower is constructed from the utterances of visitors to it, constantly reconfiguring itself according to the "artificial stupidity" of the individual letter forms. As Justin Clemens wrote in his introduction to the work:

> What sorts of conceptual figures are available to think such a thing? The very old: the Tower of Babel from the Book of Genesis, which melds the frightening possibilities of technology, language, and power in a single startling image. And the very new: swarm intelligence as an ideal that expresses how innumerable different individuals can nonetheless come to produce radical innovations in excess of the powers of any one of them -and in the midst of apparent disorder. Babelswarm is a project that draws on the most traditional elements of religion, art, and literature, as it engages with the challenges of a scientific and technological age (Clemens, Dodds, Nash, 2007).

Autoscopia is a virtual artwork by Justin Clemens, Christopher Dodds and Adam Nash, commissioned by the National Portrait Gallery of Australia. Autoscopia allows users to enter names to create virtual portraits based on internet searches. These searches manifest as web portraits dynamically generated by search results, and audiovisual animated sculptures dynamically generated in Second Life. The Second Life component closed at the end of 201 0, but the web portraits continue to grow, all the while tweeting their existence, recursively feeding themselves back into the results of future searches. Autoscopia's Second Life portraits are built using data from internet-based vanity searches' conducted within the Second Life installation. Each name creates a unique outcome composed of27 limbs'. Each limb is fed data from websites such as Google, Facebook, Twitter (and other more invasive, though publicly available, sources) etc, with colours, geometry and audio affected by variations in search volume. Data is then re-published via discrete web pages automatically composed through text and images collected during the search. The identity created will thereafter be reincorporated into future search results. Each portrait also tweets' its existence on Twitter, with

both the web pages and Tweets looping back into future portraits, creating a kind of time-based network meta-animation.

Finally, *Reproduction* is an ongoing collaboration between myself and John McCormick. The work involves experimentation in audiovisual, performative, evolving, virtual entities spawning and reproducing in virtual environments, capable of intercommunication with the material world via various systems of motion and data capture. Loosely based on principles of artificial evolution, the parameters that we as the artists initially selected are, rather than the standard artificial evolution parameters like strength and fitness, all audiovisual performative parameters like red, green, blue, opacity, rhythm, timbre, tempo, tone (pitch) and so on. The entities 'evolve', 'reproduce', 'live' and 'die' over thousands of generations according to a constantly emergent evolution of these crude parameters that is informed, but not determined, by both their interaction with humans in the material world and with their interactions with each other. In other words the original parameter set becomes, after the first generation, virtualised content for the next emergent generation. All the while, the entities are organising (or perhaps socialising) and improvising movements and 'songs' amongst themselves, whilst observing and improvising with any human visitors to their 'space'. The space in this case means both their digital virtual environment (accessible by humans via an online multi-user environment) as well as the physical space of wherever the work happens to be being exhibited. In the latter case, motion and data capture are used by the entities to perceive humans, while a modulated audiovisual display allows humans to perceive the entities. Our desire, as artists, is to engage - using sound, music, movement and dance - in what we might call a "genuine" improvisation with these digital entities, by which we mean the human and digital performers share equal responsibility and value in the emergence of the improvised performance, dynamically building a shared performative vocabulary by learning from each other's nuances, gestures and performative suggestions.

With all of these works, it is only arbitrarily possible to define the thresholds between any unified system and its environment or medium. Once again, if evaluated via their display states, it is possible to identify semi-closed circuits that "generate their own stable states" and that "grow and evolve by drift" (Parisi, 2004, p.142), but as with Ways To Wave it is not clear whether these systems, if they can be said to exist at all, are producing themselves or something other than themselves, and nor is it clear at all whether they can be said to be using their digital sensorimotor capabilities to enact a knowledge of their environment, precisely because it is unclear where the threshold of either the system or the environment lies. It is problems like these, unique to the era beyond medium ushered in by the digital that have led thinkers like Bernard Stiegler to explore concepts of "inorganic life" and technogenesis, as well as scientists like Stephen Wolfram and Edward Fredkin to formulate - in a move emblematic of Kittler's (1999) assertion that "media determine our situation" (p.xxxix)- an hypothesis of the universe as a digital computer.

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ENDNOTES

[1] I use the term 'digital virtual environment' to acknowledge pre- and non-digital virtual environments, which Lévy (1998, 28) quotes Serres as including "imagination, memory, knowledge, and religion," to which I would explicitly add music, along with any other shared conceptual environment (stories, art, myths, games and so on). See Nusselder (2009, 33-53) for a discussion of this.

[2] Having fallen out of favour after the hyperbole of the mid- to late-1990s, the term *virtual reality* is currently (2014) enjoying a resurgence, thanks to the popularity of a new generation of startlingly 1990s-like head mounted devices for realtime 3D graphics display.

[3] Some of the ideas in this section were presented in a different form as a talk at the 24th Annual Society of Animation Studies Conference, Melbourne, Australia, June 2012.

[4] Braidotti does this without explicitly referencing Simondon. It is very interesting that Guattari himself never mentions Simondon by name, given the similarity with Simondon of some aspects of Guattari's machinic philosophy, along with Guattari's decades-long collaboration with Deleuze, who was himself very heavily influenced by Simondon (Iliadis, 2013)

[5] See Mills (2011) for the confusion that arises when attempting to rationalise networked digital environments in Simondonian terms without understanding the fundamental importance of the plastic, generic state of digital data.

[6] "A body's structure is the composition of its relation. What a body can do corresponds to the nature and limits of its capacity to be affected." (Deleuze, 1990: 218)

[7] This phrase is no more or less absurd than *artificial life*

[8] Some of the ideas in this section were presented in a different format as a talk at the CODE 2012 conference, Melbourne, Australia, November 2012

[9] Conveniently, the word "programming" in the phrase "programming code" can function as both a verb and an adjective.

[10] Plato considered writing as a memory that is exterior to the human mind, a kind of 'outsourcing' of memory so to speak. Although Plato considered this undesirable, Jacques Derrida famously deconstructed the concept of hypomnesis to show that the human mind, and therefore human culture, is in a constant evolving interplay process with the written word, each informing the development of the other. This, very crudely, is a summary of Derida's concept of *différance*. (1982) Also of interest here is Stiegler's sense of tertiary memory, (1998: 255) where a tool is a kind of grammaticised memory. The concept of code as writing that I am discussing is different from, but related to, these two readings of writing as memory.

[11] The two postulates are, first, that "[t]he subsets are relatively detachable from the whole of which they are a part," and second, that "if one wants to understand a being completely, one must study it by considering it in its entelechy, and not in its inactivity or its static state." (Simondon, 2012: 3-4)

[12] vi is a text editor for Unix systems

[13] In a previous version of his manifesto (2004), Badiou used the word "Empire" instead of "the West." We can assume he means "global capitalism."

[14] Given the following exposition, it becomes clear that the phrase 'real time' can only be used in the vernacular sense to mean 'on the fly', since in strict grammatical terms the phrase is meaningless.

[15] *Cut Piece* was an interactive live art piece, where audience members were asked to use a pair of scissors to cut pieces of Ono's dress off her while she sat on a stage. Cited at http://www.medienkunstnetz.de/works/cut-piece/

[16] It also manifests, for example, as 'buffering' when loading a video on a web page, to ensure the computer has enough video in its buffer so that playback is slower than the speed of the the video downloading, to give the illusion of realtime playback.

[17] Such as in my work, *One, Another* (2009), see video documentation linked from http://adamnash.net.au

[18] If they do, we encounter the same problem but as a recursive, or what Simondon might call *reticulated*, case, which is complex and interesting, but for the sake of clarity in example, I will ignore it for now.

[19] It may be, continuing with Klein's statement above, that there is some relationship between the digital and the complex immateriality of colour. This is likely to be related to the affect cycle and so the reader is referred to my article *Affect and the Medium of Digital Data*. (2012)

[20] Aristotle, Goethe, Schopenhauer and Wittgenstein are but a few of these thinkers, and a simple web search will provide texts and references of these works. It would be difficult to name an artist who hasn't explicitly engaged with the concept of colour. Again, a simple web search will provide significant references.

[21] Given our discussion of time in digital virtual environments, this has enormous implications that there is no room to discuss here.

[22] The following points are based on research I carried out with Justin Clemens and Christopher Dodds