The Emergence of Narrative: Procedural Creation of Narrative in Artificial Aesthetic Artifacts.

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Abstract

Computational systems, as simulators or as creators of new media and messages, are gradually taking over and transforming the operational spaces of many arts. Their outputs are inher¬ently multimodal, not only relying on image, movement, sound or haptic stimuli, but also on the per-ception of logical and mathematical structures and processes, a modality that is dependent on the previous four but that is intellectual, rather than sensorial. When we are faced with an artificial aesthetic artifact, we watch it perform as we simultaneously perform it, we probe its structure and draw the connections needed to participate and to comprehend the complexity we witness; we simulate its processes — to the extent that we are able to understand them — and create our own parallel sequences of events as the artifact unfolds. As with any other aesthetic constituent of these systems, narrative and drama may either be hard-coded — much as they are in traditional or non-procedural media — or they can emerge from the programmed processes and algorithms. This paper proposes an approach to how the creation of narrative can be understood in the context of performative or interactive generative systems, in what may be their greatest contribution to the creation of a new cinema.

Keywords: Computational media, Generative art, Cinema, Narrative

Computational artifacts

Pervasive as they have become over the last decades, computational devices are now nearly ubiquitous in many aspects of contemporary cultural production and consumption. Technologi-cal arts as cinema, video or photography, regularly use them in production and presentation contexts, sometimes replacing previous analog resources, sometimes finding whole new niches or specializations for their usage.

In cinema and audiovisuals, from being used as tolls for post-production or the creation of 'special effects', computational devices became omnipresent and can now be found in most areas of production, presentation and distribution, to the extent that the entire creative and commercial cycles of cinematic arts can nowadays be integrally developed without the use of analog means.

Used as tools, computational devices allowed the discovery or invention of whole new pro-cesses but also the simulation of already existing tools, very often representing increases in speed, reductions in cost, or both, eventually replacing most analog counterparts. This was often achieved through simulation: computational devices are universal machines, able to re-produce and simulate any process that can be reduced to algorithms. Simulation was ultimately responsible for the computerization of something else besides tools, the media of the arts: film, screen, tape, etc. These were firstly digitized and then altogether absorbed by the computational devices. They became immaterial and, one could say, virtual, shedding their materiality and going through a transformation from matter to bits.

Computational devices are excellent remediators (Bolter & Grusin, 1999) and, when acting as media, promise unprecedented fidelity in reproduction, safety in archival, and extreme portabil-ity. It may be no exaggeration to claim that very often, if not always, the media that turned digital largely benefited from the transition in many aspects.

But computational media must not abide solely to the classical traits — one could say limita-tions — of analog media, among which we can find linearity, determinability and controlled access. Digital devices are perfectly suited to act in such ways. As Espen Aarseth concluded (1997) when studying William Gibson's digital text Agrippa (1992), computational media are capable of being more rigorously linear and determinable than analog media. Through the strength of the laws of code (Kittler, 2008), they allow the enforcement of controlled access in stricter ways than analog alternatives (Lessig, 2006). Computational media permit the departing from limitations of analog media; they allow non-linearity, indeterminacy and random access to be developed in scales that non-computational media are not able to achieve. They allow all of this within artifacts that are capable of various degrees of autonomy (Carvalhais, 2010), both from their creators, contexts of creation or wreaders[1], as well as from hard-coded information or other data. In many aspects, computational devices ache to be released from the constraints of the classical roles of media. They achieve permanence from transience; they simulate stillness as the outcome of dynamic processes.

As creators, our usage of computational devices must be guided by the awareness that even when acting as media they are capable of simultaneously acting as tools that operate on their media layers. They are capable of reshaping the experience, the form, content and expressive-ness of the artifacts in runtime. These computational devices, which we may call artificial aes-thetic artifacts, are capable of transforming the operational space of the arts, expanding it well beyond the field of possibilities offered by classical media. They go further, break out and construct

[1] The portmanteau word 'wreader' identifies the fusion of the acts of reading and writing that is developed in interactive computational systems where the user is very often not a passive receiver of the information but also actively contributes to the organization of the materials, to the definition of the structure of the narrative or, ultimately, to the creation of the contents of the piece. In constructive systems (borrowing Michael Joyce's term), the user is required to "create, change, and recover particular encounters within a developing body of knowledge or writing process" (Joyce, 1995) which necessarily equates his work, at least partially to that of the original creator, or writer, of the piece or system. The wreader is the human participant in the cybernetic feedback loop, the machine's cooperant in the poetic process

new spaces, being able to exert some (however limited) judgment over the products of their operation, to reconsider past choices in deciding where to follow in upcoming steps (Boden, 2004). In sum, they are able to act creatively in concert with their human cooperators.

Amodality and Multimodality

Before being conveyed as a set of sensorial stimuli, a computational artifact is built from code and software[2]. Before being expressed, it operates in an amodal space of possibilities, where a 'proto-sensory' flux preconditions the differentiation of the sense modalities (Hansen, 2004). At this state, computational artifacts can take arbitrary forms because they possess no "natural mapping, no natural principles of operation" and their "critical operations all take place invisibly through internal representations" (Norman, 1993) of a highly abstract nature.

It is only when the processes of computational artifacts are transcoded — in the sense pro-posed by Lev Manovich (2001) — that they become modal and multimodal. That is the moment when processes are brought to physical reality — a step without which they would not be expe-rienceable by humans — and are expressed through concurrent modalities. These include visu-al, audial and haptic modalities that are directly linked to the human sensorium (Whitelaw, 2008), as well as the perception of motion, that although closely related to vision can be inde-pendently analyzed as a movement-image, where motion is very concrete and perceivable (Sterne, 2006).

We can expand the definition of modality to include, as proposed by Stephanie Strickland, the perception of mathematics or mathematical structures, rhythm and harmony, the "struggle between mathematical abstractions and words" (2007). This should not be understood in the Pythagorean sense or tradition, as a correspondence between art and mathematics in terms of numerical 'harmony', but rather as the intellectual and intuitive understanding of structure and process, and the aesthetic pleasures associated to it. It is the beauty of abstract un-derstanding, not of bodily contact but of cerebral perception. It is intimately connected to the design stance that humans tend to seek in inanimate objects, or to the intentional stance sought in animate objects (Pinker, 1999). The first tries to assign a purpose to an object while the later tries to understand motivations and emotions. This modality, which we will call proce-dural, can be seen as a product of these stance identifiers in human perception.

> In new media, our task is the measure of measure. To accomplish this we write less 'with places' and more with 'transitions'. Space does open up, perhaps monstrously, to a world of currents and translations. We don't see these spaces full so much as feel them fill. We don't watch them perform; we perform them, in part, in connection with others, in processes of conjugal transfer that propagate themselves. Our probes help us draw the connections and form the perceptions needed to flow, to participate in and comprehend an increasingly complex patterning that enfolds us (…) (Strickland, 2007:42)

The first modalities are sensorial, directly dependent on vision, audition, touch and even pro-prioception — the haptic modality frequently involves more than the sense of touch, being related to movement through space or other involvements of the human body. They are frequently crossed, combined or mutually reinforced. All sensorial modalities contribute to the communication of the internal processes of the artificial aesthetic artifact to human wreaders and therefore, to the emergence of the procedural modality. The internal potential translatability that is guaranteed by code in computational artifacts must be relinquished to ensure human readability and as this happens, a further process of translation must take place. The internal translatability is not only found between modalities, but also between media — images, sounds, films, texts, and so on —, reducing programmed, self-generated and user-generated information to an equivalent code (Hayles, 2006a).

Once communicated to humans, stimuli go through reception and perception, two complimentary but nevertheless contrasting processes (Hofstadter, 2007). Reception gathers inputs that are starting points to the process of perception, where symbols are selectively triggered and meaning is inferred. The procedural modality is then not directly sensorial, as the previous, but rather cognitive and intellectual.

Illusion and simulation

The human sensorium mediates the experience of the exterior (Bateson, 1979) through illusion and simulation. Pure perception never exists through sensory channels, as the brain uses the body's specialized sensory signals to *fabricate* perception (Damásio, 2003). Objects, artifacts and the whole of reality are sensed and recreated in what invariably results in a subjective ex-perience of reality.

Often times the illusion is based on the direct reception of stimuli however, at other times it may be based on a construction of double illusions, as in the case of film — where the real motion between frames remains unseen as it creates the movement-image —, or on the stacking of multiple illusions, as in video or audiovisuals. Perception is then an epiphenomenon, "a collective and unitary-seeming outcome of many small, often invisible or unperceived, quite possibly utterly unsuspected, events" (Hofstadter, 2007:93), a large-scale illusion. Perception is subjective not only because it is an illusion and a simulation developed at a higher level than the previous sensorial creations but also — one might say, especially — because it is a process where meaning is inferred or created (Gelernter, 1998). Meaning is distilled from the sensed, from reality and media, both located in the external world from which the meaning-maker brain is irremediably isolated. The procedural understand-ing of what is perceived, the understand-

[2] This distinction is enunciated by David M. Berry, that chooses to use code "to refer to the textual and social practices of source code writing, testing and distribution (…) specially concerned with code as a textual source code instantiated in particular modular, atomic, computer-programming languages as the object of analysis (…)" and software "to include commercial products and proprietary applications, such as operating systems or fixed products of code" which he also calls "prescriptive code" (2011: 31).

ing of rhythm, structure and harmony contribute to a further, intellectually constructed simulation, that of the causal procedurality, of the algorithms that originate the perceived phenomena. Drawing from the clues available to the senses and inferred from the posterior sensorial illusions, the universal machine of the human brain recon-structs the processes or their best possible approximations, building internal simulations that predict external processes and try to anticipate them. Successful anticipation is proof of suc-cessful simulation, and a corroboration of the acquired knowledge.

Brains constantly try to reduce the perceived complexity, trying to make "unfamiliar, complex *patterns* made of many symbols that have been freshly activated in concert to trigger just *one* familiar pre-existing symbol (or a very small set of them)", to "take a complex situation and to put one's finger on *what matters* in it, to distill from an initial welter of sensations and ideas what a situation really is about." (Hofstadter, 2007:277) As Herbert Simon (1969) reminded us, in principle a simulation is not able to ever tell us anything that one does not already know, be-cause it is no better that the assumptions one builds into it — deduced from the received data — and a computer or brain can only do what it is programmed to do.

While not denying these assertions, Simon goes on to reason that there are ways in which a simulation can in fact provide new knowledge, even when one is not in possession of a com-plete or even reasonable set of data about the laws that govern a system. Abstracting the de-tails of a set of phenomena it may become easier to arrive to its simulation. "Moreover, we do not have to know, or guess at, all the internal structure of the system, but only that part of it that is crucial to the abstraction." (Simon, 1969:16) Furthermore, even incomplete and partially abstracted simulations can provide relevant data to be integrated in new models, thus contrib-uting to their development. If and when partially abstracted simulations can be compared between themselves and with the external phenomena, the process can be sped up through a quasi-evolutionary selection of those abstractions that are able to provide better matches to the external phenomena.

Naturally, a simulation may produce seemingly accurate results while being based on false assumptions, developing a process that is dissimilar to the original but that just happens to produce similar patterns of outputs. There is a wealth of examples of such approximations, to be found in natural sciences and their "skyhook-skyscraper construction (…) from the roof down to the yet unconstructed foundations" (Simon, 1969:17), in emotional responses, that help "us judge what is good or bad, safe or unsafe, while also providing a powerful communication system for conveying feelings and beliefs, reactions and intentions" (Norman, 2007:27) and even in the construction of superstitions.

An incomplete understanding of the procedural aspects of a phenomenon may indeed be enough because "what happens on the lower level is responsible for what happens on the higher level, [but] it is nonetheless *irrelevant* to the higher level", being therefore possible for the higher level to "blithely ignore the processes on the lower level" (Hofstadter, 2007:43); conse-quently, if producing accurate enough results with a sufficiently high frequency, a simulation may be judged as correct even if based on otherwise incomplete or erroneous assumptions.

This is what we find with the so-called "Eliza effect", caused by the susceptibility of people to read far more understanding than is warranted in the sensorial manifestations — especially when these are symbolic — of computational devices (Hofstadter, 1995:157). This effect bor-rowed its name from the ELIZA software, written by Joseph Weizenbaum (1976) in the mid-1960's. Weizenbaum did not name the effect but was among the first to publicly demonstrate concerns about the misunderstanding of computational systems, especially given their inability to make ethical, moral, or political judgments, indeed, any judgment at all (Hayles, 2006b).

Due to the Eliza effect, we read more meaning and understanding in symbolic sequences generated by artificial aesthetic artifacts because we simulate them using erroneous principles. We project traits like sentience, intelligence and personality onto machines that were not pro-grammed to develop them and that are absolutely unable to manifest them. We do this because these traits are the best available models to develop a simulation that may produce outputs not dissimilar to those that are witnessed.

The Eliza effect can be described as the outcome of three different but complementary phe-nomena: 1) the anthropomorphization of technology, with roots in that of animals and inanimate things; 2) the concealing of processes that are not relevant to the human-side of the interaction or may not be easily or directly understood by the human counterparts; and 3) the strong effect of surprise — or what we can also call of the "violation of expectation" (Barratt, 1980) — when interacting with a computational system.

Anticipation and violation of expectation

The mechanical operations of an artifact can very often be understood with relative ease, while the logical or algorithmic processes are, more often than not, of a higher degree of complexity. Coupled with the very high processing speeds that these devices are capable of achieving, this complexity creates a barrier to their comprehension. During the interaction with these artifacts, their aesthetic and expressive behaviors — respectively tied to the sensorial reception and intellectual perception — are simulated and predicted. As the artifact's processes unfold, one builds anticipation as to whether the predictions will be proven correct or if, on the other hand, one's expectations will not be confirmed. This intellectual tension, coupled with the key-points that allow the evaluation of the simulation, is at the foundation for the building of narrative and dramatic dynamics (LeBlanc, 2006).

As with any media message conveyed by an artificial aesthetic artifact, narrative, drama and tension may be hard-coded and reproduced. Acts and multiple arcs, stable situations and the inciting incidents that unbalance them, big events, goals, commitments, crisis and showdowns, protagonists and antagonists, accompanied by a host of other

characters, may be predefined (Bartle, 2004). When they are, however, one uses the artificial aesthetic artifacts simply as me-dia, not only not taking advantage of their added capabilities as well as partially resigning pro-cedural authorship (Murray, 1997).
Where elements of a more or less classically structured narrative do not exist, a narrative ex-perience may emerge from the tension between simulation and its validation, from the probing and mapping of the logical depth of the artifact (Gleick, 2011). As characters in a script, these artifacts can be 'flat', failing to grow or change, to significantly develop or to violate our expectations during the time of our experience, or they may be 'round', reacting to conflict or other stimuli, allowing themselves to be shaped and changed by them and, in doing so, frequently violating our expectations (not always positively, though).
Difficulty of simulation and the consequent violation of the simulator's expectations are the customary signs of non-mechanical systems. The creation of large patterns as a result of many smaller effects is one of the singular attributes of living systems (Murray, 1997:93). Throughout human history complex systems were mainly found in the natural world, not in artificiality. The products of man's labor, as the epithet 'mechanic' so well expresses, were for the most part characterized by repetition and predictability. Nature was forecastable but in many aspects erratic, at least until science provided tools for its understanding and simulation, but even then those tools were often unable to provide us with a complete understanding of the field. We however know, or believe, that for the most part there are explanations for natural phenomena and that whatever we may count as unpredictability is in fact due to our lack of knowledge.
We don't endow nature or plants with emotions or personality in the same way we do to hu-mans or (to some degree) animals or even, due to the Eliza effect, to some artificial aesthetic artifacts. All of these are at least in theory possible to simulate, although they present very different degrees of complexity. What we now start experiencing with artificial aesthetic artifacts is not fundamentally different from what we have experienced for millennia with people and animals and classical narratives, and some of the barriers we encounter in the process are effectively the same. It is people — including ourselves — that we most often try to simulate, but it is in successfully simulating people that we most often fail.
The complex patterns that form a person's 'I' cannot be studied at the level of the microm-achinery of the mind because we are congenitally unable to focus on it (Hofstadter, 2007:204), so we resort to abstractions and shortcuts, and to channels of communication such as language that, although slow, indirect and not hard-wired, allow us to develop minimally effective simulations of other people's brains (2007:213). But these will inevitably generate predictions that will most likely fail to be verified because a person's 'I' is a convoluted illusion, as are others to each other and to one self (2007:291).
"The brain is a lump of hardware artfully arranged so as to produce an I — to create the illusion that some entity inside you is observing the world that your senses conjure up." (Gelernter, 1998:23)
Furthermore, there is an added difficulty with these complex simulations, one found at the level of the referential information, of the hypotexts surrounding a person. As Hofstadter puts it,

> We are all curious collages, weird little planetoids that grow by accreting other people's habits and ideas and styles and tics and jokes and phrases and tunes and hopes and fears as if they were meteorites that came soaring out of the blue, collided with us, and stuck. What at first is an artificial, alien mannerism slowly fuses into the stuff of our self, like wax melting in the sun, and gradually becomes as much a part of us as ever it was of someone else (though that person may very well have borrowed it from someone else to begin with). (Hofstadter, 2007:251)

We are all simulating and emulating each other to varying degrees, "an inevitable conse-quence of the power of the representationally universal machines that our brains are." (Hof-stadter, 2007:266)

Procedural drama

Originating in an amodal space of possibilities, processes are mediated by the artifact. After reception and perception, what was communicated modally becomes once again amodal or metamodal, as Morbey and Steele propose (2009). We find a new abstract algorithmic domain that is similar to what Mitchell Whitelaw (2008) defines as infra-media. Procedural capacities are the key to our identification of amodal characteristics in the perceived phenomena, as they are at a later stage fundamental in the process of simulation.
The understanding of processes and their simulation are not always straightforward, as there is not necessarily a direct one-to-one mapping between the code and its modal manifestations. There is no blueprint; there are constraints (De Landa, 1997). Furthermore, each modal mani-festation may be directed by contrasting processes or be developed at disparate rates. Cross-modal expressions may be created by multiple transcodings in the same system or by multiple systems or threads operating (and transcoding) simultaneously, which they can do inde-pendently or in tandem, eventually acting on each other, etc.
The translation processes from code to form, from genotype to phenotype (Blais & Ippolito, 2006:208) are also not reversible: morphogenesis is generative and therefore it is "impossible to map exactly phenotype in to genotype, since this is the result of epiphenomena, a visible consequence of the overall system organization." (Carranza, 2001) On the perceiver's side, we are left with sensations, feelings, perceptions and symbols below which we are unable to peer; we are at a private and incommunicable space.
The outputs of artificial aesthetic artifacts fundamentally differ from what we find in most classical media because, much as nature itself, they weren't necessarily created or shaped by humans. These artifacts are rich with genera-

tive potential and they have their own aesthetic, their unique patterns of desire, their ways "of giving pleasure, of creating beauty" (Murray, 1997:94). They are inevitably mediated but due to a strong hypermediacy (Bolter, 2001) they constantly confront us with signs of what may be happening behind their sensorial expressions. It is this layer that truly marvels and that allows the experience of the artifact as a symbolic drama in which we, the wreaders, are inevitable protagonists.

References

AARSETH, Espen J. (1997). Cybertext: Perspectives on Ergodic Literature. Baltimore, Md.: Johns Hopkins University Press. ISBN: 0801855799

BARRATT, Krome. (1980). *Logic and Design: in Art, Science & Mathematics.* Guilford, Ct.: Design Books. ISBN: 155821268X

BARTLE, Richard A. (2004). *Designing Virtual Worlds. Berkeley*, Ca.: New Riders. ISBN: 0131018167

BATESON, Gregory. (1979). *Mind and Nature: A Necessary Unity.* New York: E. P. Dutton. ISBN: 0525155902

BERRY, David M. (2011). *The Philosophy of Software*. Basingstoke: Palgrave Macmillan. ISBN: 9780230244184

BLAIS, Joline, & IPPOLITO, Jon. (2006). *At the Edge of Art*. London: Thames & Hudson. ISBN: 9780500238226

BODEN, Margaret A. (2004). *The Creative Mind: Myths and Mechanisms*. 2nd ed. London: Routledge. ISBN: 0415314534

BOLTER, Jay David. (2001). *Writing Space: Computers, Hypertext and the Remediation of Print*. 2nd ed. Mahwah, N.J.: Lawrence Erlbaum Associates. ISBN: 0805829199

BOLTER, Jay David, & GRUSIN, Richard. (1999). *Remediation: Understanding New Media*. Cambridge, Ma.: MIT Press. ISBN: 0262522799

CARRANZA, Pablo Miranda. (2001). *Self-design and Ontogenic Evolution*. Generative Art Conference, Milan.

CARVALHAIS, Miguel. (2010). Towards a Model for Artificial Aesthetics: Contributions to the Study of Creative Practices in Procedural and Computational Systems. Universidade do Porto, Porto. http://carvalhais.org/+/Carvalhais2010.pdf (30/05/2011)

DAMÁSIO, António. (2003). O Sentimento de Si: O Corpo, a Emoção e a Neurobiologia da Consciência. Lisboa: P.E.A. ISBN: 9789721047570

DE LANDA, Manuel. (1997). *A Thousand Years of Nonlinear History*. Brooklyn, New York: Zone Books. ISBN: 0942299329

GELERNTER, David. (1998). Machine Beauty: Elegance and the Heart of Technology. New York: Basic Books. ISBN: 0465045162

GIBSON, William. (1992). *Agrippa (a book of the dead)*: Kevin Begos Jr.

GLEICK, James. (2011). *The Information: A History, a Theory, a Flood*. London: Fourth Estate. ISBN: 9780007423118

HANSEN, Mark B. N. (2004). *New Philosophy for New Media*. Cambridge, Ma.: MIT Press. ISBN: 0262083213

HAYLES, N. Katherine. (2006a). "The Time of Digital Poetry: From Object to Event." MORRIS, Adalaide & SWISS, Thomas, eds., *New Media Poetics: Contexts, Technotexts, and Theories*. 181-209. Cambridge, Ma.: MIT Press. ISBN: 9780262134637

HAYLES, N. Katherine. (2006b). Traumas of Code. *Critical Enquiry* (Autumn), 136-157.

HOFSTADTER, Douglas R. (1995). Fluid Concepts and Creative Analogies: Computer Models of the Fundamental Mechanisms of Thought. London: Allen Lane. ISBN: 0713991550

HOFSTADTER, Douglas R. (2007). *I Am A Strange Loop*. Cambridge, Ma.: Basic Books. ISBN: 9780465030781

JOYCE, Michael. (1995). *Of Two Minds: Hypertext Pedagogy and Poetics*. Ann Arbor, Mi.: University of Michigan Press. ISBN: 0472095781

KITTLER, Friedrich A. (2008). "Code (or, How You Can Write Something Differently)". FULLER, Matthew, ed., *Software Studies: A Lexicon*. 40-47. Cambridge, Ma.: MIT Press. ISBN: 9780262062749

LEBLANC, Marc. (2006). "Tools for Creating Dramatic Game Dynamics". SALEN, Katie & ZIMMERMAN, Eric, eds., *The Game Design Reader: A Rules of Play Anthology* (pp. 438-459). Cambridge, Ma.: MIT Press. ISBN: 0262195364

LESSIG, Lawrence. (2006). *Code: Version 2.0*. New York: Basic Books. ISBN: 9780465039142

MANOVICH, Lev. (2001). *The Language of New Media*. Cambridge, Ma.: MIT Press. ISBN: 0262632551

MORBEY, Mary Leigh, & STEELE, Carolyn. (2009). *Beyond the Remix: Clarifying Mastery in Virtual Environments*. Media in Transition Conference, Cambridge, Ma. http://web.mit.edu/comm-forum/mit6/papers/Morbey.pdf (27/05/2011)

MURRAY, Janet H. (1997). Hamlet on the Holodeck: The Future of Narrative in Cyberspace. Cambridge, Ma.: MIT Press. ISBN: 0262631873

NORMAN, Donald A. (1993). Things That Make Us Smart: Defending Human Attributes in the Age of the Machine. New York: Basic Books. ISBN: 0201626950

NORMAN, Donald A. (2007). *The Design of Future Things*. Philadelphia, Pa.: Basic Books. ISBN: 0465002277

PINKER, Steven. (1999). *How the Mind Works*. London: Penguin Books. ISBN: 0140244913

SIMON, Herbert A. (1969). *The Sciences of the Artificial*. Cambridge, Ma.: MIT Press.

STERNE, Jonathan. (2006). "The Death and Life of Digital Audio". *Interdisciplinary Science Reviews, 31*(4), 338-348.

STRICKLAND, Stephanie. (2007). "Quantum Poetics: Six Thoughts". KAC, Eduardo, ed., *Media Poetry: An International Anthology*. 25-44. Bristol: Intellect. ISBN: 9781841500300

WEIZENBAUM, Joseph. (1976). *Computer Power and Human Reason: From Judgment to Calculation*. San Francisco, Ca.: W. H. Freeman and Company. ISBN: 0716704633

WHITELAW, Mitchell. (2008). "Synesthesia and Cross-Modality in Contemporary Audiovisuals". *Senses & Society, 3*(3), 259-276.