

Art and Technology: coherence, connectedness, and the integrative field

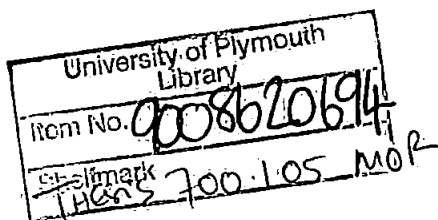
by

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### **ABSTRACT**

This thesis is a theoretical and practical intervention in the field of art and technology. It proceeds from the re-examination of four specific domains that in the past 40 years have considerably informed the invention of new aesthetic forms. They are: art, science, nature and technology. We have identified that each one of these domains and the way they inform one another reflects the influence of a Western analytical tradition based on fragmentation, dichotomies and dualities. In consequence of this, art of the last decades has suffered from a sort of mechanistic thought which results from a predominantly weary aesthetic model, founded in dualities such as: object/process, form/behaviour, meaning/information.

The main question that the present study addresses is how to overcome this predominantly reductionist inheritance and to develop an aesthetic model able to interconnect in an integrative fashion those disparate domains, respective discourses and practices? The answer to this question, developed throughout this thesis, is an aesthetic principle built upon the notions of resonance, coherence and field models, rooted in an integrative view of living organisms based on the theory of biophotons. This constitutes the main contribution of the thesis to new knowledge.

The theoretical approach of this thesis is developed upon the revision of the concept of form, supported by a *Gestalt* analysis as provided by Rudolf Arnheim, and has involved the consideration of the ideas of Gilbert Simondon (the concept of “concretisation”) and Vilém Flusser (the concept of “apparatus”), in order to gain a deeper insight into the nature of technology.

In conclusion, the practice-based methodology of this thesis has been to develop artworks based on the confluence of living organisms (plants) and artificial systems in order to permit empirical observation and reflection on the proposed theory. The major outcome of the practice is the artwork “Breathing”, a hybrid creature made of a living organism (a plant) and an artificial system. The creature responds to its environment through movement, light and the noise of its mechanical parts and interacts with the observer through his/her act of breathing. This work is the result of an investigation into plants as sensitive agents for the creation of art. The intention was to explore new forms of artistic experience through the dialogue of natural and artificial processes.

## LIST OF CONTENTS

<b>Introduction</b>	<b>18</b>
<b><u>PART I: TECHNOLOGY</u></b>	
<b><u>Inside the black box</u></b>	<b>24</b>
<b>1 The apparatus</b>	<b>24</b>
1.1 Flusser's philosophy	26
1.2 From magical to historical consciousness, the dialectic between images and texts	30
1.3 Imaging codes	35
1.4 The "apparatus-operator complex"	43
1.5 Playing with information, from <i>homo faber</i> to <i>homo ludens</i>	48
1.5.1 Order and structure	53
1.5.2 Taking the observer into account	59
1.6 Being experimental. Hacking the apparatus programme	63
1.7 Considerations and directions	70
<b>2 Works of art as vehicles of aesthetical information</b>	<b>72</b>
2.1 From meaning to information, rethinking the logic	76
<b><u>PART II: ART</u></b>	
<b><u>Technical objects, aesthetic organisms and field behaviour</u></b>	<b>86</b>
<b>3 On technological beings</b>	<b>86</b>
3.1 Gilbert Simondon brief biography	87
3.2 The technical object and its concretization	89
3.2.1 From abstract to concrete form	93
3.2.2 Process of invention	95

<b>4</b>	<b>The aesthetic organism</b>	<b>97</b>
4.1	Form as a diagram of forces	98
4.2	From “immobile objects” to interactive systems	103
4.3	Metastability and field behaviour	115
4.4	The behaviourist artwork as a hyperorganism	124
4.5	The hyperorganism gestalt	127
4.5.1	Structure and functionality	129
4.5.2	The subject matter	132
4.5.2.1	The environment	135
4.5.2.2	Conceptual model	139
4.5.3	Equilibrium	144
4.6	Towards an organic theory of art	148

### **PART III: SCIENCE**

	<b><u>Biophotonics and the Integrative Field Approach</u></b>	<b>154</b>
<b>5</b>	<b>The biophotonic model</b>	<b>154</b>
5.1	Understanding photon basic principles	157
5.2	What are biophotons?	158
5.3	Biophoton, historical background	162
5.4	Criticism of “mitogenetic radiation” and biophotons	165
5.5	Elements of biophoton theory	173
5.5.1	Coherence a key concept	173
5.5.1.1	Coherence basic principles	176
5.5.1.2	Coherence in biological systems	117
5.5.2	Delayed luminescence	179
5.5.3	DNA as source of light	181

<b>5.6</b>	<b>Material, methods and techniques</b>	<b>182</b>
5.6.1	Photomultipliers (PMTs)	182
5.6.2	CCD imaging system	183
5.6.3	Scientific exchange at International Institute of Biophysics - IIB	192
5.6.3.1	Methods and Materials	192
5.6.3.2	Results and comments	194
5.6.3.3	Practical investigation of delayed luminescence and biocommunication	195
<b>5.7</b>	<b>Biological implications</b>	<b>201</b>
<b>5.8</b>	<b>How biophoton interacts with art – aesthetic implications</b>	<b>205</b>
5.8.1	Form and coherence	210
5.8.2	The observer and negative entropy	213
5.8.3	Art as a field phenomenon	217

#### **PART IV: NATURE**

	<b><u>Leaves System - Practical Work</u></b>	<b>223</b>
<b>6</b>	<b>The Leaves System Project</b>	<b>223</b>
<b>6.1</b>	<b>Background</b>	<b>224</b>
6.1.1	Why plants?	225
6.1.2	The work of Sir Jagadish Chandra Bose	227
6.1.3	Plants as sentient beings	233
6.1.4	General concept	235
<b>6.2</b>	<b>Works</b>	<b>236</b>
6.2.1	“Happiness”	236
6.2.2	“Ephemera”	237
6.2.3	“Equilibrium”	239
6.2.4	“Breathing”	240

<b>7</b>	<b>Conclusion</b>	<b>245</b>
<b>8</b>	<b>Bibliography</b>	<b>249</b>
<b>9</b>	<b>Appendices</b>	<b>276</b>
<b>9.1</b>	<b>Apendix 1 – Author’s publication, conferences and seminar’s list</b>	<b>276</b>
<b>9.1.1</b>	<b>Publication list</b>	<b>276</b>
<b>9.1.2</b>	<b>Conferences and lectures</b>	<b>277</b>
<b>9.1.3</b>	<b>Composite sessions attended</b>	<b>277</b>
<b>9.1.4</b>	<b>Seminars attended</b>	<b>277</b>
<b>9.1.5</b>	<b>Workshops attended</b>	<b>278</b>
<b>9.1.6</b>	<b>Participation and organization of events</b>	<b>278</b>
<b>9.1.7</b>	<b>Exhibitions</b>	<b>278</b>
<b>9.2</b>	<b>Apendix 2 - Technical details of the practice works</b>	
	<b>“Equilibrium” and “Breathing”</b>	<b>279</b>
<b>9.2.1</b>	<b>“Equilibirum” electronic circuit</b>	<b>279</b>
<b>9.2.2</b>	<b>Original circuit designed by Lucas George Lawrence</b>	<b>280</b>
<b>9.2.3</b>	<b>Simplified electronic circuit utilized on this project and technical commentary</b>	<b>281</b>
<b>9.2.4</b>	<b>Arduino code</b>	<b>282</b>
<b>9.3</b>	<b>Apendix 3 - Plant based works</b>	<b>286</b>
<b>9.4</b>	<b>Apendix 4 – Marco Bischof Interview</b>	<b>289</b>
<b>9.5</b>	<b>Apendix 5 - DVD content</b>	<b>296</b>

## LIST OF FIGURES

<b>Figure 1:</b> Image of concepts. © 2009, Guto Nóbrega.	36
<b>Figure 2:</b> Alignment of image, camera and the world. © 2009, Guto Nóbrega.	37
<b>Figure 3:</b> Schematic diagram of a general communication system. © 2009, Guto Nóbrega.	50
<b>Figure 4:</b> Information aesthetic universe diagram based on the model outlined by Flusser. © 2009, Guto Nóbrega.	51
<b>Figure 5:</b> Arnheim's example of a square and circle. Source: (Arnheim 1974b, p. 4).	55
<b>Figure 6:</b> Flusser's unidirectional communication system. © 2009, Guto Nóbrega.	61
<b>Figure 7:</b> Summary of Flusser's ontological theory of technical image and apparatus. © 2009, Guto Nóbrega.	64
<b>Figure 8:</b> Basic scheme for a convoluted structure of information and meaning. © 2009, Guto Nóbrega.	65
<b>Figure 9:</b> Nam June Paik, "Magnet TV". Source: (Baigorri, 2006).	67
<b>Figure 10:</b> Screen image from the site <a href="http://www.wwwwwww.jodi.org/">http://www.wwwwwww.jodi.org/</a> .	69
<b>Figure 11:</b> Schematic diagram of a general communication system. Source: (Shannon 1948).	73
<b>Figure 12:</b> Causal vs. Acausal explanations of an event. Redrawn from McCauley's (2005, p. 60) diagram.	79
<b>Figure 13:</b> Interrelational diagram of artist, artwork and observer. © 2009, Guto Nóbrega.	85
<b>Figure 14:</b> In this photograph Simondon shows how the internal structure of the telephone remains the same. Source: (Simondon [1958] 1989).	91
<b>Figure 15:</b> The maddona of Würzburg. Photo Zwicker, Würzburg.	

Source: (Arnheim 1974b, p. 56).	102
<b>Figure 16:</b> View of <i>Almacén de Corazonadas</i> as it was exhibited in “Emergentes” at Laboral. Source: (Lozano-Hemmer 2008).	105
<b>Figure 17:</b> Lygia Clark <i>Bicho de Bolso</i> 1966 - Maria Cristina Burlamaqui Collection Aluminium 12 x 13cm. Source: (Clark 1966).	108
<b>Figure 18:</b> Aesthetic organism structure. © 2009, Guto Nóbrega.	128
<b>Figure 19:</b> “Solarsoundmodul”. Source: Ralf Schreiber (2009b).	131
<b>Figure 20:</b> “Living Particles”. Source: Ralf Schreiber (2009b).	132
<b>Figure 21:</b> <i>Maraná</i> . Source: (Esparza 2009).	136
<b>Figure 22:</b> <i>Diablito</i> . Source: (Esparza 2009).	137
<b>Figure 23:</b> <i>Autótrofos Inorgánicos</i> . Source: (Esparza 2009).	137
<b>Figure 24:</b> Screens captured from the Esparza’s video <i>Proceso</i> (Process). The pictures show Esparza collecting technological scrap, selecting mechanisms for the creation of a robot. Source: (Esparza 2009).	138
<b>Figure 25:</b> “Alexitimia”. Source: (Adi 2005).	139
<b>Figure 26:</b> SAM and its creator. Source: (EMPA 2009).	142
<b>Figure 27:</b> Equilibrium © 2009, Guto Nóbrega.	148
<b>Figure 28:</b> “The photoelectric effect. Incoming photons on the left strike a metal plate (bottom), and eject electrons, depicted as flying off to the right.” Source: Wikipedia.	158
<b>Figure 29:</b> Clockwise from left top: flying and glowing <i>Photinus pyralis</i> ; Female of <i>Lampyris noctiluca</i> ; a wave of billions of <i>Lingulodinium polyedrum</i> dinoflagellates, a phenomenon also known as “red tide”. Source: Wikipedia.	159
<b>Figure 30:</b> Intensity range of biophoton emission phenomena against human eye sensitiveness and instrumentation. Source (Inaba 2000; Kobayashi 2009).	160
<b>Figure 31:</b> Biophoton spectral frequency range.	161



<b>Figure 32:</b> Set up of Gurwitsch's experiment with onion roots. (Popp 2003a).	<b>164</b>
<b>Figure 33:</b> "Mitotic figures (left) follow the field patterns of cavity resonator waves (right) under the boundary conditions of the cell under observation. The spatial pattern follows, as usual, classical electrodynamics. The time-behaviour has to be described in terms of coherent states" (Popp and Yan 2002).	<b>169</b>
<b>Figure 34:</b> Properties of Biophotons. Source: (Popp 2006a).	<b>170</b>
<b>Figure 35:</b> Biophoton image. Source: Kobayashi Lab (2009).	<b>171</b>
<b>Figure 36:</b> Rod cell system. Source: (Pierce 2009).	<b>174</b>
<b>Figure 37:</b> Diagram of a light sensitive rod cell. Source: Source: (Pierce 2009).	<b>175</b>
<b>Figure 38:</b> Light interference pattern. Source: (Skullsinthestars 2009).	<b>176</b>
<b>Figure 39:</b> Thomas Young's "Double Slit" experiment. Source: (Skullsinthestars 2009).	<b>177</b>
<b>Figure 40:</b> "Hyperbolic decay kinetics of simulated light emission from a batch of synchronously developing early <i>Drosophila</i> embryos" (Ho 1993; p. 125).	<b>179</b>
<b>Figure 41:</b> Photomultipliers (PMTs). Source: wikipedia.	<b>183</b>
<b>Figure 42:</b> Spatiotemporal variation of biophoton. Source: (Kobayashi 2009).	<b>184</b>
<b>Figure 43:</b> The 12 anatomic spots for CCD imaging. © (Wijk et al. 2006).	<b>185</b>
<b>Figure 44:</b> The first column (A, D, G) shows ultra-weak photon emission measured with the CCD image system. The second column (B, E, H) shows photographs taken under weak illumination. The third column (C, F, I) shows anatomic spots for photo counting using movable photomultiplier. © (Wijk et al. 2006).	<b>186</b>
<b>Figure 45:</b> The first column (A, C) shows ultra-weak photon emission measured with the CCD image system. The second column (B, D) shows photographs taken under weak illumination. Source: (Wijk et al. 2006).	<b>187</b>
<b>Figure 46:</b> CCD camera and light-tight chamber. © Guto Nóbrega.	<b>188</b>

<b>Figure 47:</b> “Halo-like” patterns that appear in-between adjacent string beans. Source: (Creath and Schwartz 2005b).	<b>189</b>
<b>Figure 48:</b> On the left side is the control leaf. On the right side is the leaf submitted to the healer’s intention, showing less biophoton emission. Source: (Connor et al. 2006).	<b>191</b>
<b>Figure 49:</b> Clockwise from top left: Seed selection, dark chamber with two PMTs on top and cuvettes positioned. © 2007, Guto Nóbrega.	<b>193</b>
<b>Figure 50:</b> Ploton-count series T4. Source: (Gallego 2007).	<b>195</b>
<b>Figure 51:</b> Delayed luminescence experiments. © 2007, Guto Nóbrega.	<b>197</b>
<b>Figure 52:</b> Delayed luminescence experiments. © 2007, Guto Nóbrega.	<b>198</b>
<b>Figure 53:</b> Gonyaulax Polyedra. Source: (Hastings n.d.).	<b>199</b>
<b>Figure 54:</b> Gonyaulax Polyedra experiment. © 2007, Guto Nóbrega.	<b>200</b>
<b>Figure 55:</b> Destructive and constructive interference. (Popp 2003b).	<b>201</b>
<b>Figure 56:</b> <i>Daphnia magna</i> Strauss. Source (Forschung 2009).	<b>203</b>
<b>Figure 57:</b> <i>Daphnia magna</i> Strauss photon emission counting. Source: (Popp 2003b).	<b>204</b>
<b>Figure 58:</b> Patterns of biophoton emission. Popp sound experiment. Source: (Lillge 2001).	<b>207</b>
<b>Figure 59:</b> "Bio Photon : Allelopathy" 2007. Source: (Takahiro, 2008)	<b>208</b>
<b>Figure 60:</b> Invention. © 2009, Guto Nóbrega.	<b>213</b>
<b>Figure 61:</b> Reception. © 2009, Guto Nóbrega.	<b>214</b>
<b>Figure 62:</b> Information. © 2009, Guto Nóbrega.	<b>217</b>
<b>Figure 63:</b> Integrative field – iField. © 2009, Guto Nóbrega.	<b>218</b>
<b>Figure 64:</b> Morphic resonance. © 2009, Guto Nóbrega.	<b>219</b>
<b>Figure 65:</b> Leaves System. © 2009, Guto Nóbrega.	<b>223</b>
<b>Figure 66:</b> Darwin’s plant experiments and the resulting drawings. Source: (Hangarter 2000).	<b>226</b>
<b>Figure 67:</b> The “Optical-Pulse Recorder”. Source: (Geddes 1920; Bose 1926).	<b>230</b>

<b>Figure 68:</b> The “Magnification Crescograph”. Source: (Geddes 1920; Bose 1926).	<b>231</b>
<b>Figure 69:</b> The “Resonant Recorder”. Source: (Geddes 1920; Bose 1926).	<b>232</b>
<b>Figure 70:</b> “Happiness” © 2007, Guto Nóbrega.	<b>237</b>
<b>Figure 71:</b> “Ephemera” © 2008, Guto Nóbrega.	<b>238</b>
<b>Figure 72:</b> “Equilibrium” © 2008, Guto Nóbrega.	<b>239</b>
<b>Figure 73:</b> “Breathing” © 2008, Guto Nóbrega.	<b>241</b>
<b>Figure 74:</b> Wheatstone bridge. Source: Wikipedia.	<b>243</b>
<b>Figure 75:</b> Wheatstone bridge with a plant as sensor. © 2009, Guto Nóbrega.	<b>244</b>
<b>Figure 76:</b> BEAM “Microbug”. © 2008, Guto Nóbrega.	<b>279</b>
<b>Figure 77:</b> “Equilibrium” uses two circuits of this kind, one for each propeller. In the final circuit the position of the LDR was swapped with of the 10K pot, so the “avoiding light” was achieved. © 2008, Guto Nóbrega.	<b>280</b>
<b>Figure 78:</b> Lucas George Lawrence’s circuit for “experiments in electroculture” Source: (Lawrence 1971).	<b>280</b>
<b>Figure 79:</b> Breathing electronic circuit. . © 2008, Guto Nóbrega.	<b>281</b>

## LIST OF ABBREVIATIONS

AL	=	artificial life
CCS	=	coincident counting system
CCD	=	Charge-coupled device
DL	=	delayed luminescence
IIB	=	International Institute of Biophysics
LLPE	=	low-level photon emission
PMT	=	photomultiplier

*To my parents Elza, Genival and my brother Luciano.  
To my wife Patrícia Freire and my sons, Thiers and Theo.*

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## AUTHOR'S DECLARATION

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Graduate Committee.

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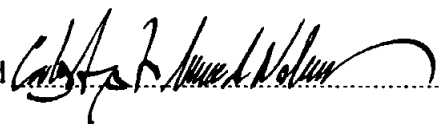
The practical projects related to the thesis and developed during the period of four years of studies under the Planetary Collegium doctoral programme are detailed in the section of this document entitled “Works”.

A DVD that documents the practice work through images and videos is annexed to this manuscript.

Publications related to this thesis, relevant scientific seminars and conferences regularly attended are listed in Appendix I

Complementary information about art projects, publications, lectures and conferences is also available online at: [www.gutonobrega.co.uk](http://www.gutonobrega.co.uk)

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Date 28-10-2009.....



## **Introduction**

This thesis emerges in resonance to four main strings of an instrument we use to call reality: art, science, nature and technology. Therefore, the methodology of the present study is articulated in four key areas of knowledge: aesthetics, epistemology, ontology, and, for reasons that are justified throughout this manuscript, technicity. The intervention of this thesis does not proceed from a historian's point of view. The critical lens through which the following analysis is elaborated is art. The discussion presented by this research develops from an artistic perspective and it gives the thesis its tonal focus. The primary concern is the use of metaphor as a tool of knowledge. Consequently, as an outcome, the new knowledge will be expressed in the form of theory and art practice.

The motivation to focus specifically on the domains of art, science, nature and technology emerges from how the intertwining of these threads informs the invention of new aesthetic forms. Artworks emerge in resonance to the way each one of these domains communicates to one another. The problem observed by this study rises from the fact that the prevailing understanding that each one of these fields reflects a Western analytical tradition based on fragmentation, dichotomies and dualities, as many scholars have already identified (Koestler and Smythies [1968] 1972; Ho 1993; Pickering 1995).

This reductionist tendency, in vogue for at least the past hundred years, conflicts in straight opposition to a natural countermovement towards integration and coherence, of which the best example is the living organic form. The consequence of this problem can be observed through an increase in materialism and disjunctions, concealed under the promise of a world integrated by the interconnectivity and immateriality empowered by the use of technology. Reflecting this trend, arts have suffered from the effects of a instrumentalisation through which technology is applied as a tool in order to fulfil a move

from a past object-oriented formalist aesthetic to a process-oriented behaviourist aesthetic (Ascott 1966; 1967; Burnham 1968a). Mistakably, the focus of some art practices has been in how to make things behave rather than asking questions about the nature of behaviour.

This sort of mechanist confluence of technology and arts is symptomatic of a predominantly weary aesthetic model founded in dualities such as object/process, form/behaviour and meaning/information. Having identified this problem, the thesis invested in a re-examination of art, science, technology and nature in order to build an aesthetic model that may be able to provide an integrative account of these apparently disparate domains and their respective discourses. There are a number of questions that have oriented the whole course of this study: How can an aesthetic model and practice be built in order to incorporate issues of interactivity, immateriality and complexity without getting trapped into technocentric materialism? How should technology and art intersect so that aesthetic experience could be levelled to a richer dimension of consciousness, revealing the matrix of interconnectivity within the artist, artwork and observer<sup>1</sup> triad? How can the status of intuition, intention, affection, absorption or meaning, which are inherent to the arts, be integrated effectively and affectively into technologically-assisted art?

As a result of these questions and the following investigation of them, the new knowledge produced by this thesis is an aesthetic principle built upon the notions of resonance, coherence and field models, rooted in an integrative view of living organisms. Parallel to the theoretical approach presented in this thesis, a practice-based methodology is employed that develops artworks based on the hybridization of natural (in this case plants) and artificial systems in order to permit empirical observation and reflection on the ideas

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<sup>1</sup>Several terms have been used to identify the subject that interacts with technologically-assisted artworks. He/she has been called an interactor, agent, vuser (a term used by Bill Seaman as a combination of viewer/user (Seaman 2002)). The term observer is used here in consideration to his/her categorisation in quantum physics, as an active presence constantly collapsing the system.

being proposed. The result of this practice contextualises the investigation about nature and is reported in the final part of this thesis. The major work presented is “Breathing”, a hybrid creature made of a living organism (a plant) and an artificial system. The creature responds to its environment through movement, light and the noise of its mechanical parts and interacts with the observer through his/her act of breathing. This work is the result of an investigation of plants as sensitive agents for the creation of art. The intention was to explore new forms of artistic experience through the dialogue of natural and artificial processes.

The thesis is organised in four consecutive parts in which the domains under discussion are examined. Part I, “TECHNOLOGY. Inside the black box”, is dedicated to the investigation of technology through the theoretical lens of Vilém Flusser and his notion of technology as an “apparatus”. The argument developed in the first section of Part I focuses upon an analysis of the modern technology of the photographic camera which, according to Flusser, problematises the apparatus in its embryonic form. The motivation to open the discussion with Flusser is two-fold. Firstly, Flusser provides a framework to situate the discussion about technology out of the predominant discourses of digital media. In Flusser’s approach, digital technology is considered as a further development of a new paradigm instantiated by technology in modernity, of which, one of the main shifts is from “work” to “information”. Secondly, the photographic model adopted by Flusser, due to its simplicity, allows the investigation to be refined into the essence of technology and to develop creative strategies accordingly. Emphasis is placed on experimentalism as the main form of intervention to acquire creative freedom in the regime of the “operator-apparatus complex”. Part I continues to introduce the discussion of information and aesthetics instantiated against the backdrop of Flusser’s concept of “habit”. Flusser’s ideas will be contrasted with that of Rudolf Arnheim and the notion that “order and structure” cannot be

kept outside the equations of information and entropy in the evaluation of works of art. Meaning and information cannot be taken apart. The issues opened up throughout Part I lead to an examination of the role of the observer and the artist in the creation of art and prepares the ground for the analysis of the fundamental structure of art: the artist-artwork-observer complex.

Part II, "ART. Technical objects, aesthetic organisms and field behaviour", extends the analysis of technology and focuses upon the technical object. Part II begins with a section dedicated to the work of Gilbert Simondon, in which "the mode of existence of technical objects" (Simondon [1958] 1989) is investigated. The theoretical focus of this section is situated within Simondon's two major concepts: concretization and individuation of technical beings. Concretization refers to the process in which technical objects become individuals, or in other words, coherent wholes. The aim of this section is to situate the technical object not as a thing but as a process of becoming. The main argument developed further in this section is that only when technological systems are seen as processes of becoming can their essence, their "technicity", be fully accessed. The section titled "Process of invention" analyses how the agency of technical beings interlaces with that of the artist in the process of invention. The notions of concretization and individuation outlined by Simondon are fundamental in understanding the concept of "hyperorganism" and "aesthetic organism", which is developed in the section titled "The aesthetic organism". The main intervention in this section is reviewing of the dichotomy between form and behaviour with the support of Rudolf Arnheim's *Gestalt* theory. The argument resulting from this discussion is that form should be understood in the context of a diagram of forces. Therefore, forces are processes that precede form. Form and behaviour are linked by force fields. This discussion is situated in a revision of the behaviourist model and the integration

of the theories of form, inherited from organicistic<sup>2</sup> analysis, into behaviour. The result is an original approach to the motto “forms of behaviour” as being the locus of an organic integrative field. This integrative field is given the title of “iField”.

Part III, “SCIENCE. Biophotonics and the integrative field approach”, informs the theoretical basis in which a branch of contemporary biophysics called “integrative biophysics” has framed living organisms. The analysis of this research field provides a major step towards an organic theory of art. The living organic theories addressed in this section are fundamentally based upon the research of the physicist Fritz-Albert Popp (who coined the term biophoton), his research group and the work of the geneticist Mae-Wan Ho. This part of the thesis highlights how biophotonic theory suggests the existence of a non-mechanistic network of information, both within and between organisms, as a fundamental source of their evolving process. Central to biophotonics is the transmission of information mediated by photons coming from a coherent field. From this point of view, living organisms are understood not as an aggregation of functional elements, but as a coherent communicative whole. This framework, as well as congruent modes of bio-communication involving the non-mechanistic interconnection of systems, will serve as the basis for introducing a theoretical model for aesthetics based on the notions of coherence and integrative fields. This model, strongly based on an organic perspective of the artistic process, is fully developed and analysed in the final section of this part, titled “How biophoton interacts with art – aesthetic implications”.

Part IV, “NATURE. Leaves System - Practical Work” is dedicated to the practice aspect of this research that emphasises the hybridization of natural and artificial forms. Leaves System is the umbrella title for a series of art projects that encompass the body of practice developed during the course of the present study. This section reports on these

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<sup>2</sup> Related to the theory of Organicism (Haraway 1976).

practices through the following sub-sections: “Background” and “Works”. The works developed by the author and reported upon in this section are: “Equilibrium”, “Happiness”, “Ephemera”, and the major work “Breathing”. Although the works “Happiness” and “Ephemera” fall into the category of video art, they are significant pieces that support the construction of the combined body of theory and practice. These works allowed the author to delve into the realm of plants and the metaphors of affection and interconnection between humans and nature. Without these works the level of commitment to this subject would not be achieved. In the context of the argument of this thesis, these works are different forms of aesthetic organisms but can be considered no less alive.

The conclusion provides a brief summary of the main aspects and outcomes of the thesis and directs to potential future research that intends to develop further the notion of fields and the organic model of aesthetics. It is understood that the work discussed and documented throughout this thesis is a first step into a land that is not fully explored. Nowadays, we live in the paradox of an increasing materiality empowered by the invisible flow of information that engenders new everyday technological forms. It seems that the old dualities such as body and soul have transmuted into new contemporary forms. As a mirror we create realities that reflect our inner organic nature, bodies empowered by living forces. In order to understand the world outside, it may be the case that we need to have a closer look into our inner organic selves, into our nature and try to understand, not just how, but why our forces cohere. This body of ideas is what gives orientation to this thesis.

An appendix is presented at the end of this manuscript that includes the author’s publication and conferences list, technical details of the practice works “Equilibrium” and “Breathing”, an interview with the science writer Marco Bischof, a list of plant-based work researched during the completion of this thesis and an outline of the contents of the DVD’s.

## **PART I: TECHNOLOGY**

### **Inside the black box**

#### **1 The Apparatus**

The present study begins by dealing with the issue of technology with the goal of trying to grasp what technology might mean in its essence. It is understood by this thesis that contemporary artists dealing with information technology cannot avoid such a concern if their objective is to develop creative freedom beyond a technocentric point of view. To fulfill such a goal the artist should not limit their studies to the matter of understanding how certain techniques have informed past artistic practice. The new medium called technology and its technical objects requires an artistic awareness to what is concealed beyond the mechanical structures, electronic circuitry, codes and electric energy. The core of technology holds its technicity<sup>3</sup>; from a creative perspective it is only with a clear understanding of the logic that drives technicity that one will be able to develop dialogues with innovative repertory.

In this thesis, the essence of technology is examined through the critical lens of two authors, Vilém Flusser (1920-1991), whose philosophy we are going to examine in the first part of this thesis, and Gilbert Simondon (1924-1989), addressed in the second part that is dedicated to art. Both philosophers, from their particular point of view, provide access to the core of technology in order to develop an understanding of it against the backdrop of aesthetics. These discussions will begin with a study of Vilém Flusser and his notion of technology as an “apparatus”.

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<sup>3</sup> This term will be developed in our examination of Simondon’s philosophy of the individuation of technical objects.

The essence of technology was focus of Martin Heidegger's often cited 1955 lecture, "The Question Concerning Technology", where he sets out a critique of modern technology. In this work Heidegger primarily asserted that the essence of technology "is by no means anything technological" (Heidegger [1954] 1977). His concern was the subject of human existence and how technology is related to it. To understand what is at stake in such a relationship, Heidegger suggested the questioning about technology must be put in terms of not *what it is* but of *how* technology refers to the ontological way things reveal themselves. Heidegger's concept of technology is based on the matrix of Greek ideas: *poiēsis* (producing, bringing-forth, naturally or artificially), *tekhne* (production by means of technique), *epistēmē* (aggregated knowledge) and *alethēia* (in the sense of revealing truth). On the relation between nature and technology Heidegger claimed that, as nature reveals itself through a natural *poiēsis*, technology is a process of revealing through technical means.

It is the power to reveal nature by technical means that emerges in the modern era with the idea of harnessing nature, as a result of a misleading reductionist interpretation of technology according an instrumental vision of causality: "revealing" to take advantage and control. In modernity nature appears as a complex of forces liable to be calculated. What has been often missing on arguments that support this view is that being part of nature, control might turn against our own freedom.

Addressing similar ontological issues to Heidegger, Vilém Flusser examines the controllability and programmability introduced by modern technology embodied in the form of an apparatus. However, Flusser differs from Heidegger as he guides us towards possible domains of freedom in the territory of technology. This guidance is based upon the deconstruction of the photographic camera as an example of a primordial technological model that informs the apparatus in its most embryonic form. Differing from scholars in the



field of media arts, Flusser does not undertake an analysis of the technical image on the basis of representation and neither does he consider photographs as based on the “optic figurative logic” (Couchot 1993, p. 42) contrasting with the “new numerical<sup>[4]</sup> visual order” (*Ibid.*) brought by digital revolution. As a result of Flusser’s argument it will be noted that the idea that digital technologies instantiated a revolution cannot be fully sustained. If there is a revolution in course it would have rather started with a new consciousness initiated by the modern conception of technology, in which the notion of “information” replaces that of “work”<sup>5</sup>. Flusser regards this moment as the time in which the photograph was invented. As a result of this discourse, the digital shall be seen as the apex of a revolution and not its cause. This position has been adopted in this thesis in order to recognise the significance of reframing digital information into a new discourse, contrary to the notions of immateriality and disembodiment, which is embedded in post-humanistic studies (Hayles 1999), and the suggested obsolescence of the human body against the convergence of all media into the digital (Kittler 1999)<sup>6</sup>. The model that is aimed to be developed here is integrative. From this perspective, the thesis is looking for theories, works and ideas that support a notion of coherence, enabling the apparent separation of nature and technology to form an interconnected whole. The philosophy of Flusser provides useful insights in pursuit of this goal, which is the subject of the following sub-section.

## 1.1 Flusser’s philosophy

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<sup>4</sup> Numerical here refers to digital technology.

<sup>5</sup> This concept will be fully developed in the section “Playing with information, from *homo faber* to *homo ludens*”.

<sup>6</sup> In his book “Gramophone, film, typewriter” Friedrich A. Kittler stated: “With numbers, everything goes. Modulation, transformation, synchronization; delay, storage, transposition; scrambling, scanning, mapping – a total media link on a digital base will erase the every concept of medium. Instead of wiring people and technologies, absolute knowledge will run as an endless looping” (Kittler 1999, p.2)

The philosopher and writer Vilém Flusser was born on May 12<sup>th</sup> 1920 in Prague, Czechoslovakia, into a family of Jewish intellectuals. He began his philosophical studies at the Juridical Faculty of Karlsuniversität in Prague but moved with his family to London after the occupation of the city by the Nazis in March 1939. Living in London with his wife Edith Barth he continued his studies at the London School of Economics. After losing much of his family during the Second World War, Flusser immigrated to Brazil in 1941 where he lived for thirty-one years and held Brazilian citizenship. In the beginning of his career in Brazil he occupied a post as manager of an electric transformer factory, whilst also proceeding and concluding his education. Flusser published his first articles on linguistics and philosophy on the *Suplemento Literário do Estado de São Paulo*. In 1962, he became a member of the Brazilian Institute of Philosophy, and was designated professor of philosophy of communications at *FAAP* (School of Communications and Humanities) in São Paulo (Flusser 1984). In the 1970s he returned to Europe where he lived until his death in 1991.

During the 1980's Flusser's theories had come to the attention of a number group of intellectuals, most of whom were artists. However, as a philosopher, Flusser remained an outsider, never becoming totally integrated to an "accepted history of philosophy" (Ströhl 2002, p. x). According to Andreas Ströhl (*Ibid.*), director of the Goethe Film Institute in Munich, it was not until his death in 1991 that his unconventional thought was recognised within academic circles of European media studies, being compared to theorist at the level of Walter Benjamin or Martin Heidegger. Resonances between the work of Marshall McLuhan and Flusser may be found on new media literature (Kukielko and Rauch 2008; Canán 2008) but the most substantial influence on his philosophy is acknowledged to be Edmund Husserl. Husserl's phenomenology furnished Flusser with the structural basis for his particular perspective on technology and led him to recognise a "motivating (*movens*)

force behind all the contemporary social and technological change”, which he addressed as the “apparatus-operator complex” (*Apparat-Operator Komplex*) (Ströhl 2002, p. xii)<sup>7</sup>. For Flusser there was no reason to differentiate the apparatus from its operator since, from a phenomenological point of view, both exist complementing each other in a relational fashion<sup>8</sup>. Flusser treated this integrated whole as a “black box” (*Ibid.*), a concept that will be examined in more detail in the following sections. Before concluding this brief introduction to Vilém Flusser it is important, for the purposes of contextualisation, to unfold some of his influences and resonances.

Flusser addressed the phenomenon of technological revolutions and constantly evoked the idea of “paradigm shift”, which he borrowed from the epistemologist and historian of science Thomas Kuhn. Flusser merged this idea with Werner Heisenberg’s quantum theory, leading to his insight that changes in a certain technological model should be considered according to the idea of discontinuous quantum leaps, rather than a linear and transformative progression. In Flusser’s view, a new consciousness emerges from such changes and their inherent new codes.

In the same manner that the alphabet was directed against pictograms, so digital codes currently direct themselves against letters, to overtake them. In the same manner that a form of thinking based on writing opposed itself to magic and myth (pictorial thinking), so a new form of thinking based on digital codes directs itself against procedural, “progressive” ideologies, to replace them with structural, systems-based, cybernetic modes of thought (...) This can no longer be thought dialectically, but rather through Kuhn’s notion of “paradigm”: no more a synthesis of opposites, but rather a sudden, almost incomprehensible leap from one level to another. (Flusser cited in Ströhl 2002 p. xiii)

Flusser’s philosophy is rather dialogical, than dialectical. He emphasises a reality formed on the relations between things as opposed to the things in themselves. This way, he

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<sup>7</sup> In this context, the word “complex” derives from Flusser’s phenomenological approach to media technology and it refers to an “invisible oneness” (Ströhl 2002) formed by the operator/apparatus relationship.

<sup>8</sup> As Ströhl observes, Flusser differs from Heidegger for his argument “does not concern itself with the producing machine”. For Flusser what is of interest is to think of the “information-processing apparatus”. In his view, “[d]espite its apparent treat to humanity, technology is mostly an aid to humanization”. (Ströhl 2002, p. xxxiv)

persuades us to focus on the dialogue, rather than on the speaker. Ströhl puts it quite clearly (2002, p. xiii):

Flusser juxtaposes the traditional notion of a world that contains “hard” objects and subjects to his own concept in which only the relations between subjects and other subjects are the concrete. Man is an interpolation, something like a node in a network of interactions and possibilities. (...) the Self is a node in an entire network of connections.<sup>9</sup>

It is such a dialogical and humanistic aspect of Flusser’s philosophy that means he is useful in an investigation of the broader problem dealt with by this study, namely, the creation of technologically assisted artworks. The point investigated by this thesis is whether and how within a technological framework there is room for creative freedom. This question, in principle, may appear ingenuous, however, the investigation of this point is supported by the fact that the development of the field of interactive arts over the past few decades reflects, in great amounts, an embracing of technological solutions for the purpose of making the artwork “work”, particularly in making the artwork responsive to the observer’s presence (either on site or remotely)<sup>10</sup>. In the following analysis, supported by the work of Flusser, this thesis will show how the creation of technologically assisted art is,

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<sup>9</sup> This conception of Self approximates Flusser to Roy Ascott, to whom not only new digital technologies with telematic networks and the metaverse, but also ancient vegetal technologies (which Ascott refers to as “vegetal reality” (VR)) (Ascott 2003b; 2009), enable access to a more permeable idea of Self in which multiple possible Self identities are made possible. Rather than a crystallized sense of Self common in Western traditions, spiritual practices, as well as aesthetic experiences – and it seems to be one of the main points where the use of technology is relevant – seem to break with the idea of an unified identity to promote, through immersion and connectiveness, a sense of sharing an affective space in which the Self may assume a more impersonal and fluid state. Ascott also suggests that certain mind states such as schizophrenia, characterised by abnormalities in brain functioning, should not be regarded from only a pathological point of view, but also considered as a particular condition that belongs to “any sort of creative activity” (Ascott 2009). This also resonates with the concept of man as an “interpolation”, which displaces the focus from the objectiveness of being to a process of becoming, a point that will be investigated in detail in the next chapter under the lens of Simondon’s concept of individuation.

<sup>10</sup> In this respect the recent exhibition at the Kinetica Art Fair 2009 serves as an example. Developed in partnership with the Kinetica Museum, this art fair focused on kinetic, robotic, sound, light and time-based art featuring well-known and emergent artists in the fields of kinetic, electronic and new media art. Despite a few inquisitive artworks that invited the audience for some sort of dialogue, most of the exhibition appeared to be concerned more with a discourse on what it is possible to do with technological means. “Wall of Eyes”, by the artist Adrian Baynes, is an interactive artwork in which 255 mannequin eyes balls mounted on a wall follow the viewer through the gallery space. In spite such an unusual scenario, which may catch one’s attention, the artwork seems to find its conceptual basis on a metadiscourse that “literally” informs us, by means of technological resources, that the artwork sees us. In that sense, what was once left to the subjective apparatus of the viewer, and all potential dimensions it may unfold, is now reduced to the interactive functional game between subject and object.

to a certain extent, always held under the constraint of a particular logic embodied in a form of what Flusser came to call an apparatus.

## **1.2 From magical to historical consciousness, the dialectic between images and texts**

In 1983 Flusser published in German a discrete volume called *Für eine Philosophie der Fotografie*<sup>11</sup> (Towards a Philosophy of Photography, published in Portuguese as *Filosofia da Caixa Preta*), which turned out to be acclaimed as his seminal work in the field of new media studies. In this book Flusser sets out a critical analysis of technology developing a completely new system of relations that is in some aspects both different and complementary to previous examinations, such as those performed by Martin Heidegger and Walter Benjamin.

Flusser developed his argument grounded on three major cultural revolutions, the culmination of which taking place in the post-industrial era with the development of the photograph. From his perspective, such an achievement demarked a radical epistemological change in the creation of images, epitomising a new relation between man and modern technology. Flusser begins his analysis by suggesting that the first revolution occurred in the pre-historical age, a moment in which man begins to codify the four spatiotemporal dimensions of the world into the two dimensional space of a plane, rendering, the “out there” imaginable. For Flusser imagination is “the capacity to produce and decipher images, the capacity to codify phenomena in two-dimensional symbols, and then to decode such

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<sup>11</sup> An English translation of this book only appeared in 1984 in Germany and 2000 in England (Ströhl 2002, p. xxxii). Despite his death in 1981, the legacy of Flusser within media studies has slowly gained attention within academic circles (Cubitt 2004). Such a delay may be mostly attributed to the lack of translation of his works, especially for Anglophones. Flusser was fluent in five languages but his most important texts were written in German, Portuguese and French.

symbols” (Flusser 1984, p. 8). Consequently, images mediate man and the world, and they do so in such a way that the observer and the image get caught in a circular time, a time of magic set in a category completely different from linear historical time.

Linear time events are established through chains of causalities. In turn, the magical time of images is reversible, circular, meaningful and relational. The example given by Flusser is the relation between the cock and the Sun. “[I]n the historical world, sunrise is the cause of the cock's crowing; in the magical world, sunrise means crowing and crowing means sunrise. Images have magical meaning” (*Ibid.*). As Flusser underlines it, the magical character of the images must be considered in order to decipher their meaning<sup>12</sup>. Pre-historical images “originate from magical consciousness, and they produce magical behavior in their addressees” (Flusser [1989] 2002b, p.126).

Images were meant to mediate man and the world, rendering the latter to imagination. In doing so, however, the image also interposed itself between them. They became screens instead of maps and no longer helped to decipher the world but projected themselves upon it, transforming the world into a screen-like scenario to be experienced. This distortion of the original function of images led to what Flusser considers “idolatry” (Flusser 1984, p. 7).

In the course of this problem a second revolution took place, and linear writing was created with the purpose to “translate scenes into processes” (Flusser 2002b)<sup>13</sup>. This

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<sup>12</sup> As will be elaborated further on, the technical image of the post-industrial era proceeds by an inversion of its primordial function. Ubiquitous in contemporary life, images will project their magical character over “reality”, restructuring it into “a image-like scenario” (Flusser 1984, p.7). According to Flusser, what is at stake in that reversal is “a kind of oblivion Man forgets that he produces images in order to find his way in the world; he now tries to find his way in images. He no longer deciphers his own images, but lives in their function. Imagination has become hallucination” (*Ibid.* 1984, p.7). Despite the fact that one may find immediate resonance between Baudrillard’s theory of simulations and Flusser, the latter essentially differs from the former as for Flusser there is no meaningful distinction between reality and virtuality (the world of technical images), as “no meaningful distinction can be drawn between reality and representation, for they differ only in degree of probability, not in essence” (Ströhl 1995).

<sup>13</sup> Author’s translation from Portuguese. As Flusser wrote several of his works in Portuguese, including a personal translation of *Für eine Philosophie der Fotografie*, a parallel can be traced between different

method involved codifying the bi-dimensional world of images into the linear, unidimensional system of writing. For Flusser (1984, p. 7), the invention of writing was meant to “destroy the screen [of images] in order to open the way to the world again”. This operation also involved the transcodification of “the circular time of magic into the linear time of history” (*Ibid.*), creating “historical consciousness” (*Ibid.*).

Linear writing (especially the alphabet) was invented to replace magical consciousness and magical behaviour with enlightened consciousness and historical action. Linear texts explain images, they roll out their scenes into processes, and they order things into irreversible chains of causality. The environment can be causally explained and progressively manipulated. Texts are instructions for a progressive way of dealing with the environment. Their goal is to explain away all images. The following is the enlightened goal of history: to identify all imagined events as historical happenings. (Flusser [1989] 2002b, p. 126)

In this passage Flusser addresses the subject of technological innovation from a seemingly anthropological and phenomenological point of view. As has already been commented, for Flusser the problem of technology is not technology in itself, but rather how it reflects changes in states of consciousness that cannot be analysed in a procedural manner, for chains of cause and effects may be interlocked in non-linear way. Such an understanding and methodology requires an “extrahistorical perspective” (Flusser cited in Ströhl 2002 p. xii). As a result, if we want to grasp the essence of modern technologies we need to pay attention to the context in which inventions such as photograph were created. This requires us to consider the historical dialectics between texts and images.

Texts result from the process of codifying planes and surfaces into lines, abstracting all aspects of the phenomena with exception of one: the conceptual. The lack of conceptual phenomena in writing is because texts refer to surfaces – the imagetic plane once decoded from the concrete world – but not the world directly. Texts are a step further away from conceptual phenomena, which paradoxically man wanted to approximate; they are an

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versions of this document. We are quoting in the present analysis Portuguese expressions, which are not present in the English version, hoping to enrich and clarify the understanding of Flusser’s ideas.

abstraction of a second order. “Concepts do not signify phenomena but ideas” (Flusser 2002b, p. 10)<sup>14</sup>. Conceptualisation, in this sense, is the capacity to codify and decodify texts<sup>15</sup>. Texts do not interpose themselves between man and the world, but between man and the images. They were meant, in the first place, to explain images and make them intelligible.

Along with texts, historical images “fill them with imagination” (Flusser [1989] 2002b, p. 127). Historical images are images that originated from historical consciousness, but work in polarity against historical consciousness as they attempt to bring an imaginative, magical consciousness to it. This is why Flusser considers such a conjoint of forces as dialectical. They operate through opposing forces. From their dialectical positions text and image mutually reinforce one another. Texts explain images and images, in turn, illustrate texts - making their meaning comprehensible and imaginable. Images bring back to texts the circular time of magic that they struggle in tearing apart. From this, “texts becomes more imaginative, and images become more conceptual” (*Ibid.*). According to Flusser, “this dialectic, by means of which images become more conceptual and texts more and more imaginative, is the dynamic of history” (*Ibid.*, p.127).

It is this dynamic that is put at risk with the invention of letterpress printing – which allowed reproducibility and distribution of texts and images – and when texts reached their highest degree of abstraction, as it is found for instance in pure sciences. Texts spread out throughout the world, opaque and unimaginable, giving rise to what Flusser understands as “textolatry” (*Ibid.*, p. 9). In this context, man progressively stopped being served by texts to gradually become slaves of their ideologies. Scientific texts are good example of this phenomenon as they are often incomprehensible, not only by the layperson but also the

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<sup>14</sup> Author's translation from Portuguese.

<sup>15</sup> Computer imagery is a useful example of images representing a higher degree of concepts.



expert mind. This concern was epitomised in the famous quote of the Nobel Prize-winning physicist Richard Feynman: “If you think you understand quantum mechanics, then you don’t understand quantum mechanics” (Edwards 2006).

When texts cease to inform images and vice-versa, when the dialectic between text and image begins to stop, it is the announcement of the end of historical consciousness. It is exactly in the apex of such a crisis, in the early 19<sup>th</sup> century, that the photograph was invented. According to Flusser, not by coincidence, the objective was “to render texts imaginable again, to charge them with magic, and thus, to overcome the crisis of history” (Flusser 1984, p. 9). In order to tackle such a task,

(...) the new images had to assume certain characteristics of printed texts. Like texts, they had to become mechanically producible, reproducible, and distributable, and their value had to be contained in the *information* that they carried rather than in their material base. (...) This called not only for change in image making, but also for *apparatuses*. From this point on, image makers could no longer produce images. Instead, image makers required to work together with technicians. Later, owing to advances in automation, image makers became ever more superfluous, so that today fully automatic apparatuses produce, reproduce, and distribute images, although this cannot be called “art” in the modern sense of the word, it is about powerful models of experience. (Flusser [1989] 2002b, p. 127, italics added)

In the following section we will examine the emergence of the technical image, focusing on the specific case of the photograph, which according to Flusser, is an embryonic model for the understanding of a culture dominated by the use of apparatuses that predominates a calculating, formal thought. What is important to bear in mind is that Flusser develops his examination of techno-cultural revolutions in terms of consciousness shifts. The dialectics between image-thinking and writing-thinking was structural for the emergence of an historical consciousness that was opposed to the magical consciousness inhabited and nurtured by images.

We are still trying to grasp a new shift of consciousness resulting from the information technologies we have developed out of the post-industrial context. This new consciousness is inevitably hybrid, arising from interactions between moist and dry matter,

from the flow of natural and artificial organic processes. Apparently, this new consciousness leads to the awareness of coherence and resonance present in communication processes, of which the use of technology has taken a major role. To develop and apply the concept of coherence and resonance in the context of communication systems, such as those created as artwork, is the main goal of this thesis.

### **1.3 Imaging codes.**

The technical image, epitomised in the photographic model, represents a step moving even further away from the phenomenological world. Ontologically speaking, images could be classified in the following way: traditional images that are hand-made are abstractions of first degree; they abstract two dimensions of the “real” perceivable world, codifying it into surfaces that served as mediation between the world and a future observer (Flusser 1984, p. 10). Hierarchically they preceded texts, which were inscriptions of a second order and abstractions from the world of images. The technical images in turn, according to Flusser, are abstractions of a third order. They represent concepts in the first hand; they are images produced by an apparatus, which is a “product derived from applied scientific texts” (*Ibid.*).

In the case of the photographic camera, already in its infancy, the production of image is the result of knowledge-based concepts – namely, chemical reactions, optics and mechanics and nowadays more sophisticated laws (see fig. 1).

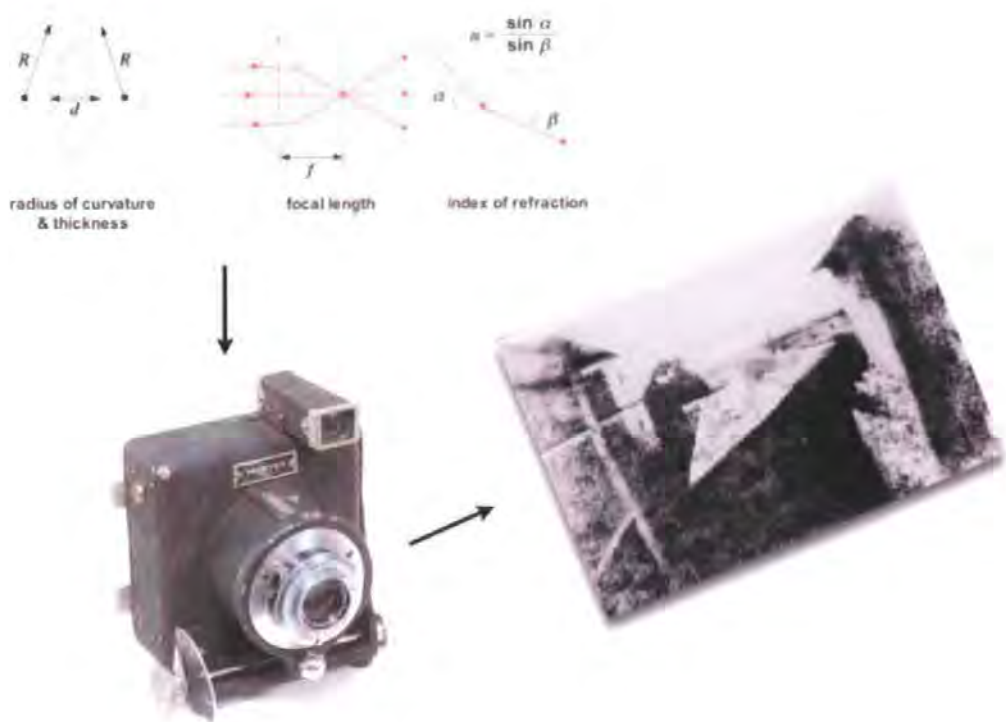


Figure 1: Image of concepts. © 2009, Guto Nóbrega.

This technicity is not immediately apparent. The efficiency of the apparatus – in automatically making images that appear purely as inscriptions of the “real” world – renders its system transparent to the eyes of an unaware observer. Such an alignment between the light, which the phenomenal world reflects or emanates, and the sensitive surface inside the camera creates the illusion that the technical image engendered by the photographic process is derived from the world in a causal chain of connections of which the photographic image is the final stage (see fig. 2). As Flusser points out, it seems as if the technical image and its meaning coexisted in the same level of reality (*Ibid.*, p. 10).



**Figure 2:** Alignment of image, camera and the world. © 2009, Guto Nóbrega.

Several scholars would disagree with Flusser that the photographic image represents first hand concepts and not the world as it is out there. The visual artist and leading scholar in the field of technologies of the image, Edmond Couchot, is one such scholar. Couchot offers an alternative view of photography that will now be contrasted with that of Flusser's, allowing further refinement of the argument presented here.

Couchot argues that the invention of the photograph represents a further stage in the evolving process of figuration techniques that have taken place since the *Quattrocento* with the advent of the perspective of central projection, but which still operates under the "optic figurative logic" as found in the *camara obscura*. The fundamental feature of the *camara obscura* was the capacity to capture the light reflected by an object in the physical world. Such a light, in the form of luminous rays, crosses a small orifice in the front of the *camara*

*obscura* and projects the image of the observed object in its interior. Thus, in the *camara obscura*, the object and its image are aligned. Such an optical system constitutes the basis of what Couchot determines “morphogenesis by projection” (Couchot 1993). Couchot goes on to say that the same principle is present on the photographic camera, with the difference that in the latter, due to a technological advancement such as the inclusion of lenses and a light sensible plate, the image is automatically registered. Morphogenesis by projection, Couchot asserts, “implies always the presence of a real object pre-existing to the image. It creates a biunivocal relation between the real and its image. It follows that the image occurs as representation of the real” (*Ibid.*).

Flusser argues that such an understanding of the photograph reflects a misconception and a lack of critique of its allegedly indicial realistic character:

This apparent non-symbolic, “objective” character of technical images has the observer looking at them as if they were not really images, but a kind of window on the world. He trusts them as he trusts his own eyes. If he criticizes them at all, he does so not as a critique of image, but as a critique of vision; his critique is not concerned with their production, but with the world “as seen through” them. Such a lack of critical attitude towards technical images is dangerous in a situation where these images are about to displace texts. (...) The uncritical attitude is dangerous because the “objectivity” of the technical image is a delusion. They are, in truth, images, and as such, they are symbolical. In fact, they are even more an abstracted, symbolical complex than traditional images. They are meta-codes of texts, and (...) they mean texts and only very indirectly do they mean the world, “out there.” Technical images owe their origins to a new type of imagination, the capacity to transcode concepts from texts into images. What we see when we look at technical images are newly transcoded concepts concerning the world “out there.” (Flusser 1984, p. 10).

The problem with Couchot’s argument is that in analysing the photographic image as a sort of signature of the real he conceals the operation that goes on within the camera. Couchot’s discussion is set in terms of the automatism of the technical image that achieves plenitude with the invention of the digital technology. Couchot seemingly investigates the development of digital technologies in terms of an evolution of figurative techniques. Each step on the history of the technology of the image is addressed as a succession of innovations implemented by artists, whom he also identifies as “experienced engineers”

(Couchot 1993, p. 37). The gradual evolution of technical means is examined by Couchot as if it was driven by human necessity and desire, resulting from the goal since the *Quattrocento* to search obsessively for a gradual automatization of the processes of creation and reproduction of the image; an “automatization which could liberate more and more the eyes and the hands” (*Ibid.*)<sup>16</sup>. Couchot asserted that for the progression of the automatization of figurative techniques it was necessary to master the analytic processes that allow to breaking down the image into its elemental constituents. For example, the image was decomposed into lines in order to be transmitted elsewhere, a new feature found in the invention the pantelegraph, the machine that is regarded as the forerunner to the television<sup>17</sup>. Even the impressionist artists are seen in Couchot’s analysis under the logic of a collaborative commitment towards the synthesis of the image. Through techniques such as pointillism and divisionism, artists began to synthesise coloured shapes into optical mixture of dots and small strokes (*Ibid.*, p. 38). These successive developments of inventive solutions were, though, oriented by a common goal: to find the minor constituent element of the image that could be analysed, manipulated and controlled. Such a pursuit was achieved and a new numerical figurative logic has arisen out of the advent of the pixel.

As the work of Erwin Panofsky ([1927] 1991) and Pierre Francastel ([1951] 1990) has already informed us, art history and its correlated techniques cannot be interpreted as an apparent series of linear developments. Its narrative refuses to obey any sort of mental scheme that attempts to situate the dynamic of its events into a mere goal-oriented project (Campos 1990, p. 58). For both these art historicists, art history cannot be conceived without a correlation between events and the chronology of cultural circumstances. It is in this sense that this thesis considers the direction provided by Flusser more productive in the

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<sup>16</sup> Author’s translation from Portuguese.

<sup>17</sup> For a comprehensive account of the passage from optic technologies of the image to the numerical techniques, see Couchot’s book *Images, de l’optique au numérique* (1988).

context of this research. Flusser highlights that behind the apparently linear causality that defines the photographic image as purely result of light inscription, there is a strong conceptual operation that involves the pre-codification of scientific knowledge in the photographic camera. In Flusser's argument, the photograph is the direct result of those programmed codes that define the photographic system, the apparatus. Flusser's model shifts the discussion of programmability, information, automatism which is normally set in the context of digital technology and by doing this, provides a simple model to analyse modern technology. Flusser's analysis provides a deeper understanding of the context in which digital technology took form and allows more elaborated strategies in resonance to that context. It is important to state that behind the discussion set around the technical image, the focus of interest for the argument outlined here is placed on the shift in consciousness that supported the appearance of such an image. Understanding the succession of conceptual shifts that lead to its appearance allows the research to understand the logic behind the mechanism that provides the technical image - the apparatus. Our intention in discussing the photographic image is not to delve into a semiotic analysis of the photograph as used by authors such as Roland Barthes (Barthes 1982), Susan Sontag (Sontag [1977] 1990) or Philippe Dubois (Dubois 1994). The goal here is to articulate a philosophical standpoint based on an alternative analysis of the technical image in its seminal form. For Flusser, the calculating, formal logic of the technical image – already present in the embryonic form of the photograph – is representative of a cultural, social and political paradigm shift. On the other hand, the analysis taken by Couchot overlooks such an issue, placing focus on the newness of the digital information technologies. For Couchot (Couchot 1993), as well as for several theorists of new media (Quéau 1993; Kittler 1999; Hansen 2004), digital technologies are the founder of a new revolution. The adherence between the image and the concrete world, inherent to the “optic figurative logic” of past

media such as analogue photography, video and cinema, is taken as a platform to spread the radical new features of the digital. The digital represents the new paradigm of a total rupture with the real through the instantiation of a “new numerical visual order” (Couchot 1993, p. 42). As he asserts:

“The numerical image does not represent the real world anymore, but simulates it. Rebuilds it, fragment by fragment, proposing a numerical visualization which does not maintain any direct relation to the real, neither physical, nor energetic. (...) It makes the figurative logic enter into the era of simulation.” (Couchot 1993, p. 42)<sup>18</sup>.

Therefore, with digital technology the umbilical cord between the concrete world and its image is cut. Digital technology puts itself to the service of a new imagination in which the signifier and its image are not ontologically attached. Such a view encourages the post-humanistic claims of disembodiment and immateriality.

For Flusser, however, the objectivity between image and the world is not the issue at hand, as it has never existed before. Images, including the photographic ones, are symbolic in essence. What Flusser considers in his analysis of the photograph is not the documentary essence of such a technical image or the ratio between the object and its representation<sup>19</sup>. His methodological analysis of the photographic medium “takes up the notion of calculation, of computation and of projection” (Ströhl 2002, p. xxv). Flusser looked into structures of communication instead of its resulting messages, allowing him to unpack the photographic medium beyond its alleged objective representational aspect. Taking this direction he avoided getting trapped into and reinforcing a hegemonic Western visual logic. Rather, Flusser set the basis of a philosophy for the new regime under which post-industrial technical systems, driven by the hierarchy of programming, codes and functions, operate. According to Flusser, such philosophy is necessary if

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<sup>18</sup> Author’s translation from Portuguese.

<sup>19</sup> For more in this respect see the work of Roland Barthes (1982), Susan Sontag ([1977] 1990) or Pierre Bourdieu (1996).



we are to lift photography into full consciousness. (...) because photography may then serve as a model for freedom in the post-industrial context. Thus, the task of a philosophy of photography is to show that there is no room for human freedom in the realm of the automated, programmed and programming apparatus; and having shown this, to argue how, despite apparatus, it is possible to create room for freedom. The task of a philosophy of photography is to analyse the possibility of freedom in a world dominated by apparatus; to think about how it is possible to give meaning to human life in the face of the accidental necessity of death. We need such a philosophy because it is the last form of revolution which is still accessible for us. (Flusser 1984, p. 59)

Flusser truly believed that in a world of apparatuses there is still room for human expression, differentiating his works from apocalyptic visions such as those present in the philosophy of Baudrillard, to whom in such a world (dominated by virtual realities)

(...) is the system of representation that is at issue. The image that he has of himself is virtualized. One is no longer in front of the mirror; one is in the screen, which is entirely different. One finds himself in a problematic universe, one hides in the network, that is, one is no longer anywhere. What is fascinating and exercises such an attraction is perhaps less the search for information or the thirst for knowledge than the desire to disappear, the possibility of dissolving and disappearing into the network.

For Flusser it is not true, since an informational networked environment can also be emancipatory, as soon as we critically accept the “new consciousness” necessary to engage with such a structure. He states that,

[i]n the same manner that a form of thinking based on writing opposed itself to magic and myth (pictorial thinking), so a new form of thinking based on digital codes directs itself against procedural, “progressive” ideologies, to replace them with structural, systems-based, cybernetic modes of thought. (Flusser cited in Ströhl 2002 p. xiii)

The way for freedom, Flusser suggests, involves learning how to play the apparatus game; to play against its constituting logics. That is the reason why instead of jumping into discussions of particular issues such as interactivity, complexity, immateriality, Virtual Realities, and connectivity from a technocentric point of view, this study, initially, takes a step back to analyse the context in which these subjects are inserted in. From such a standpoint we understand that the innovations and transductions – using a term rooted in Gilbert Simondon’s theory of technicity (Simondon [1958] 1989) – made possible by information technologies will have the benefit of a model from which a critical point of

view could be set. Therefore, this research has avoided approaching theories in which the radical innovation of numerical technologies is considered as causing a radical technological shift when, in the argument developed here, they are instead part of a pre-existing paradigm. This paradigm was inaugurated when images no longer resulted from the pure process of imagination but instead became produced, reproduced and distributed by fully automatic information systems – an operation which the digital technologies continually make more efficient and subtle.

The next section will focus on the notion of apparatus, analysing its bond with its operator as an “apparatus-operator complex”. This analysis allows the thesis to develop a further understanding of another kind of complex, made of apparatuses and humans, that is the focus of this research, the artist-artwork-observer triad. It is intended through this discussion to show points of resonance between art practice in the confluence of art, science and technology and the broader perspective that is formed under the normative regime of apparatuses.

#### **1.4 The “apparatus-operator complex”**

The apparatus is essentially a machine programmed to function in a certain way, producing only what is already encoded in its program. The range of scale of an apparatus may go from the micro or the nano to large scale administrative apparatus. In fact, the apparatus must be thought of as a system rather than a material object. Flusser used the photographic camera as a model because he saw it as the simplest and most transparent of all apparatus. As has been discussed, the image produced by this apparatus is one of a very special kind, for it does not refer directly to the phenomenal world, as pre-historical images

did, but indirectly to the applied scientific texts the apparatus is made of. In that sense all informational logic of the digital appears to be already latent in the photographic system, and not differing from it.

Because such codes (knowledge-based concepts) are embedded in the apparatus, in principle they are not accessible to the photographer, who only sees input and output<sup>20</sup>. Consequently, Flusser thought of the “operator-apparatus complex” as a “black-box”. He observed that as the

coding process of technical images occurs inside this black box, (...) every critique of technical images must concentrate on the "whitening" of the interior of that black box. As long as criticism fails to do this, we shall remain illiterate as regards technical images. (Flusser 1984, p. 11).

The fact that the photographic camera is programmed to automatically produce technical images seemingly liberates the photographer to play and to explore its program. That is why the apparatus (in this case, the camera) must not be confused with instruments, as they are more like toys; toys to play with and combine symbols. In that sense Flusser asserts that the main function of the photographer is to play against the apparatus in order to exhaust the virtualities of its rules. From this perspective it could be claimed that photographs are potentially pre-encoded in the camera. Each photograph realised reduces the potentiality of the apparatus' program, exhausting its virtuality in order to enrich the photographic universe (Flusser 1984, p. 18). When the photographer looks through the camera it is not the world what he/she sees, but the potentialities made available through the codes embedded in the apparatus. Therefore, the photographer does not mean to change the world out there, but to instead manipulate the virtual worlds pre-encoded in the apparatus. This is one of the main differences between technical images and pre-historical

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<sup>20</sup> The photographer would need to work in the factory of apparatuses (Kodak, for instance) in order to have access to operate on the level of the software and the hardware that produces them. In fact, it is one of the turning points in regards to the creative way of dealing with technical apparatus. Artists have become programmers, or at least, they have moved towards the interior of the “black-box” to operate it from inside. This will be discussed and exemplified further on in the thesis.

images. While pre-historical images are worldviews (copies of the environment) encoded by an observer of a certain phenomenon or process, photographs are “computed possibilities (model, projections onto the environment)” (Flusser [1989] 2002b, p. 129); they bring form to concepts about the world. Pre-historical images serve to imagination while photographs serve to visualisation.

“Imagination is the ability to step back from the environment and to create an image of it (...) visualization refers to the ability to turn a swarm of possibilities into image. Imagination is the consequence of an abstraction from the environment. Visualization is the power to concretize an image from possibilities.” (*Ibid.*)

It also could be said that the fact that photographs do not operate by a process of abstraction but one of concretization<sup>21</sup> is one of the reasons to consider photographs as the first post-historical images. This is why such a system has been mistakenly analysed in terms of technique of representation, whilst in truth, as an apparatus, it operates by projection. This whole concept becomes clearer with the words of Andreas Ströhl (2002):

For him [Flusser] photography is an overcoming of the artificial separation of culture into science, technology and art. Because photography is founded on the laws of natural science and technical innovation, it successfully reintegrates the image into a linear unfolding of events and narrative of history. Thus, this flood of events can be pushed back. Photography becomes the damming up of history. Technical images freeze events into scenes. Therefore, the photograph counts as the first posthistorical image, especially because its origins in formal, calculated, unhistorical thought. From the perspective of formal consciousness, the photograph is information selected from a field of virtual pixels with a specific purpose.

The idea that the photograph and its apparatus work as dams, interrupting the stream of history, must not be confused with Francis Fukuyama controversial argument of the end of history developed in his book “The End of History and the Last Man”(Fukuyama 1992). Whereas Fukuyama addresses philosophically political and economical issues, focusing on a historical moment of equilibrium that resulted from the overcoming of communism by a liberal, market oriented democracy, Flusser’s motivation for his claim is set on the

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<sup>21</sup>As it will be explained further on this thesis when examining Simondon’s theory, the process of concretization is not only a particular feature of the operational mode of the apparatus, or “technical object” in Simondon’s terms, but fundamental to its genesis.

consciousness shift that is inherent to new modern technology. What is at a stake in Flusser's assertion is not the impossibility of historical events, which will certainly continuously occur, but "historical consciousness" that is, according to his argument, based on the "linear code of the alphabet rather than the codes of numbers"(Flusser [1989] 2002b, p. 128). When texts flow into the apparatus they are transcoded and transduced into scenes (bi-dimensional surfaces or three-dimensional systems, such as a robot); they become technical images with magical features once more, but magic of a second order without its previous historical character<sup>22</sup>. Moreover, the fact that the apparatus is based on calculating, formal thought means that modes of perception and behaviours have been modelled to operate automatically into the apparatus. Consequently, if modern technology is supposed to be an "overcoming of the artificial separation of culture into science, technology and art", as Flusser has stated, it is so, paradoxically, to the cost of excluding the human participation<sup>23</sup> in the process. This is actually the critical point towards which Flusser's philosophy is aimed, opening up a number of questions. How to overcome the deterministic aspect of the apparatus and to open space for creative freedom in a world ubiquitously occupied and programmed by machines? How to submit the apparatus program to human intentions? How to subvert the absorption of human intentions by the apparatus? Is it possible to configure creative alliances between humans and apparatuses?

These questions seem to overestimate the relation between humans and machines, mythifying machines as possessing super powers. They may also point to the opposite. They point to the incapacity of the apparatus as a result of its necessity for human intention in feeding its system with models that simulate human thought. This is the game, and it is

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<sup>22</sup> According to Humberto Maturana, what differentiates the living organism and the artificial system (a robot for instance) is exactly the ahistorical character of the artificial system's genesis, and not the matter of being or not being a molecular autopoietic system (Maturana 1997).

<sup>23</sup> By using the term participation the thesis means acting creatively and with freedom, not only feeding the apparatus to make it work or ignoring its influence in our lives and decisions.

impossible to ignore that contemporary machines are perfected to play it very well, and as such, a critique of technology must acknowledge this perspective. Flusser's critique has an impact on a society that lives in a world filled of apparatus, but it is also the direct concern of artists working with technology. Although Arlindo Machado<sup>24</sup> criticises Flusser by saying that he conceived such a relation (between the artist and the apparatus) in an excessively pessimist manner, he agrees that it is the artist's duty to unchain all the consequences inherent to the apparatus, making explicit that which would be disguised, unperceived or masked in the process of the basic functionaries of production<sup>25</sup>. Machado adds that such activity (of the artist) is contradictory; on one side it concerns the re-thinking of the concept of art, absorbing the new formative process opened by machines; on the other side, it is about making perceivable and explicit the undeclared goals of the technological project, whether these be of belligerent, authoritative (*policial*) or ideological nature (Machado 1997).

Investigations in regard to the creative mode of dealing with apparatus are still in development as of the time of this thesis. Provisory answers have been given but the deceiving character of the apparatus has neutralised several efforts on this matter. Many times good answers have been presented, but quite often for the wrong questions. The purpose of this research is to place the correct questions and to suggest possible answers on this matter. Flusser's philosophy of the apparatus is not complete, but it provides speculative directions in the way of revealing the intricate task of dealing with the apparatus in a creative and libertarian way. This is the subject to be further unpacked in the following section.

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<sup>24</sup> Arlindo Machado is professor in the post-graduation program of communication and semiotics at PUC University in São Paulo – Brazil.

<sup>25</sup> The term functionary, or fonctionnaire in the way Flusser uses it in his book "Towards a Philosophy of Photography", alludes to the person who plays with and is a function of an apparatus.

## 1.5 Playing with information, from *homo faber* to *homo ludens*

Central to Flusser's concept of apparatus in cultural terms is the awareness that "any future critique of culture must substitute the category 'work' with the category 'information'" (Flusser 1984, p. 18). According to Flusser, questions emergent from an industrial context (work) are not appropriate questions for the apparatus if we want to grasp its essence. Flusser puts it in the following way:

The category basic to industrial society is work: tools as such, including machines, work: they remove objects from nature and inform them: they change the world. But apparatus do not work in this sense. (...) The photographer does not work in the industrial sense of that word, and there is little sense in wanting to call the photographer a worker. (...) Although the photographer does not work (in the sense we use the word here), he is doing something: he produces, processes and stocks symbols. There have always been people doing something similar to that: writers, painters, composers, accountants, administrators and so on. In the process, these people produced objects: texts, paintings, musical scores, budgets, projects. These objects, however, were not consumed, as such; they were used as supports for information: they were read, looked at, listened to or played, taken into account, considered, decided upon. They were not ends in themselves, but means — they were media. This sort of activity is being taken over by apparatus in general at present. It is apparatus which produce most of the information-supports at present; they do it more efficiently and with wider scope, and they are thus able to program and control work, as such. (*Ibid.*, pp. 17-18)

The apparatus is informative in accord to the etymological sense of the word "inform", rooted in the Latin word *informare*, meaning "giving form". It could be, however, in accordance with information theory, that the apparatus and its products are meant to deliver information and that such an informative aspect of their message will depend primarily on the ratio between noise and redundancy within the process. It will rely, to a certain extent, on the adequacy of its programs, the configuration of its pre-installed symbols, and the way of manipulating them ludically. That is the reason why Flusser asserts that in the operational mode of the apparatus what counts is not the way of working with it, but of playing with it. In such an operational mode a new consciousness will form,

moving from *homo faber* to *homo ludens* (Flusser 1984, p. 19). This way, to play in a creative way with the apparatus in order to avoid a deterministic result from its logical constrains, paradoxically, would involve to play against its program, searching for undiscovered possibilities within its system<sup>26</sup>. It requires one to become an explorer of unpredictable configurations, to generate informative, and use improbable structures. It follows that the notion of information and entropy apparently takes an unprecedented role in the creative process, now focused on the dialogues with apparatus. This will now be examined more closely.

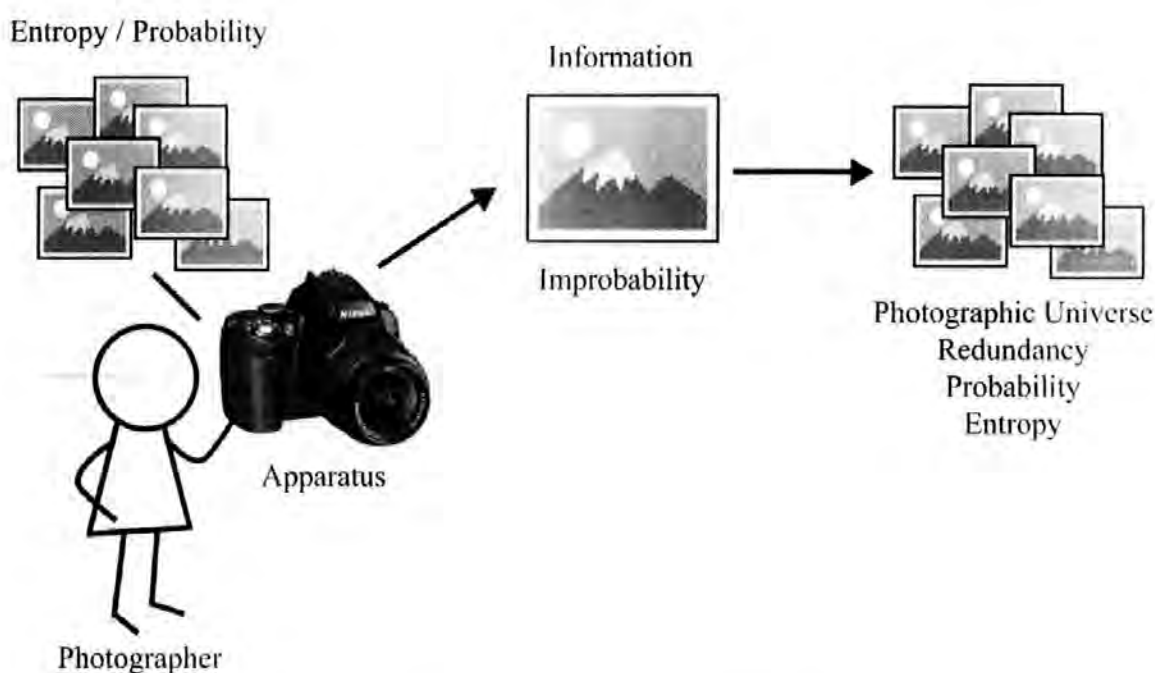
Modern theory of communication tells us that entropy “is a measure of disorder; hence negative entropy or information is a measure of order or of organisation since the latter, compared to distribution at random, is an improbable state” (Bertalanffy 1980, p. 42). In that sense, novelty in the light of the theory of information would be an improbable inversion of the second law of thermodynamics, which states that the level of probability (entropy) in a isolated system, not in equilibrium, will increase over time (Flusser 2002c, p. 51). Thus, it could be said that a field of virtual possibilities embodied in the apparatus is to be permuted, combined, and organised by the artist in order to reduce entropy and to produce relevant information. In such a framework we might see photographs as resulting from a matrix of probabilities, which becomes information to feed the photographic universe. As the photographic universe increases it becomes redundant and entropic again. In this way the photographer plays with the apparatus to inform the world with new scenes.

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<sup>26</sup> This position resonates with the concept of “play” by Johan Huizinga, which in his major treatise “Homo Ludens”, asserts that play “only becomes possible, thinkable and understandable when an influx of mind breaks down the absolute determinism of the cosmos” (Huizinga 1949, p.3). In Flusser, such determinism is embodied in the form of an apparatus. This is why play is the best *modus operandi* for the machine; it becomes a strategy. In his paper “Towards a Field Theory for Post-Modernist Art”, Roy Ascott (1980) draws our attention to the transactional character of works of art, in which a field of “psychic interplay” between the artist and the observer takes place, and proposes the artwork as a system. Thus, the artwork may be seen as a matrix around which the art game is set. This thesis’s author has proposed elsewhere (Nóbrega 2008e) that playing is the way the artist, the observer and the artwork become a whole interlinked mind, and that art is a game of which the rules are to be discovered through playing, and that in playing ludic patterns that interconnect are revealed.



These new scenes, projected into the world, program its observers who feed back the apparatus with new rules and new codes<sup>27</sup>. This is also how the apparatus evolves and becomes more complex, as it absorbs the creative intuition of the artist and incorporates new information into its technical body (see fig. 3).



**Figure 3:** Schematic diagram of a general communication system. © 2009, Guto Nóbrega.

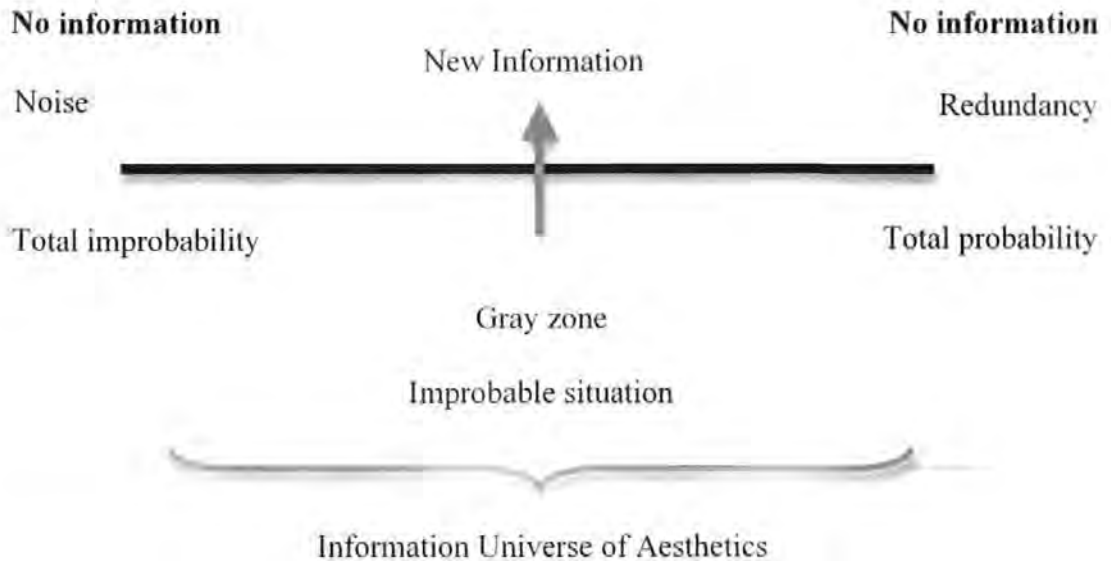
Speculating a form of criticism of art in terms of information theory Flusser defined art as “a human activity that aims at producing improbable situations, and it is the more artful (artistic) the less probable the situation is that it produces” (Flusser 2002c, p. 52). Thus, the artist is looking for the intermediary zone between two extremes of the aesthetic universe (see fig. 4):

“(…) one [extreme] is total noise, total improbability, meaning a situation that approaches the impossible; the other extreme will be total redundancy, almost total probability, meaning a situation that approaches tautology, the absence of information. Both extremes

<sup>27</sup> We are referring to the fact that the new information an apparatus launches into the world (a new experimental computer effect, for instance) is re-injected (feeds back) into the apparatus in a form of a model that allows the “new trend” to be available in the mainstream as a fashionable “effect”.

are unattainable, and they constitutes the two horizons of the universe of aesthetics.” (Flusser 2002c, p. 53)

It could be illustrated by the following figure:



**Figure 4:** Information aesthetic universe diagram based on the model outlined by Flusser. © 2009, Guto Nóbrega.

As Flusser reinforces, “much more interesting (more graspable), (...) is the imprecise passage between that extreme zone and the one that we can just stand without cracking. It is the gray zone where (...) the thundering noise begins to turn into information, because a minimum of redundancy has infiltrated” (Flusser 2002c, p. 54).

The basic criteria Flusser employed in his envisioned form of information-based criticism is “habit” (*Ibid.*, p. 52). Works of art emerge out of probability, he said, from the nausea called habit. In the long-term, even the most improbable situation (the spectrum where works of art can be expected to appear) will become habitual again. Thus, the

aesthetic “scale” would be identifying works of art in terms of how long a certain work will remain informative, new and non-habitual<sup>28</sup>.

Although this thesis takes on board Flusser’s perspective in regards to the claim that a new cultural criticism cannot ignore the notion of information in the analysis of the cultural apparatus, it is not so easy to support his notion that information, in statistical terms, can be used as criteria for the evaluation of works of art. Flusser’s idea was that a work of art could be at some point in the future criticised with basis in a “probability calculus”, as soon as the “objective and the subjective meaning of ‘new’ coincide” (*Ibid.*). “Such a quantifying criticism, which will use both physical and information theories (...) and the measurement will show the slide of works of art toward habit” (Flusser 2002c, p. 57). But would these parameters be enough to classify and identify works of art? Can one reduce the subjectivity inherent to the making and fruition of works of art to a probabilistic status? Moreover, could the observer be isolated from such a critique?

Although it is possible to agree with Flusser that the notion of information and entropy for the arts cannot be underestimated, and that it becomes even more worthy of consideration when the creative process involves the configuration of dynamical process systems, this thesis cannot agree and work with the idea of an information criticism for arts. In many ways, it would be contradictory to Flusser’s own premises<sup>29</sup>. The creative exercise

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<sup>28</sup> This scale, as Flusser has suggested it, is dynamical and moving in a loop from “ugly”, “beautiful”, “pretty”, “kitsch” and returning to ugly again. In short, “ugly” would correspond to a new improbable situation that always causes some terror. Flusser is drawing upon the poet Rainer Maria Rilke who said that “we admire beauty so much because it scorns, with nonchalance, to destroy us: each of the angels is terrible” (Flusser 2002c, p.51) also upon Russel’s example in which mentions that a “cow with a horse’s head is newer than an ordinary cow because it makes us tremble more” (*Ibid.*, p.52).

<sup>29</sup> In the article “New Imagination” (2002a, pp.115-116) Flusser states that: “only when one produces images of calculations [numerical image] instead of facts (...) can ‘pure aesthetics’ (the joy of playing with ‘pure forms’) find its true expression” and “*Homo ludens* replace *Homo faber*”. From this passage it becomes clear how the idea of information criticism might set itself with effect within the framework of a “new imagination” based in pure calculus. Flusser also expresses his concern in an existential sense on the “burdensome, but necessary, leap out of linear into the zero-dimensional (into the realm of ‘quanta’) and into synthesizing (into computation)” (*Ibid.*). It is understood from this that such “existential” concerns provides evidence of Flusser’s awareness to the fact there is a risk on this leap, the risk of losing ourselves in this magical universe

within the gray area range pointed on the diagram (see fig. 4) cannot not be assessed as a matter of calculus or resolved in terms of statistic and probability. In the arts the notion of information and entropy cannot be isolated from the concepts of structure, order and meaning. An orderly sequence of elements in a given structure may not be just redundancy, it may also refer to relevant information. As Rudolf Arnheim has emphasised, “the tempting prospect of applying information theory to the arts and thereby reducing aesthetic form to quantitative measurement has remained largely unrewarding” (Arnheim 1974b, p. 18). This is to be the subject of the following section.

### 1.5.1 Order and structure

In his essay “Entropy and Art. An Essay on Disorder and Order” (1974b), Gestalt psychologist, art and film theorist, author and professor Rudolf Arnheim re-examines the Second Law of Thermodynamics under the light of psychology of art. His focus was placed on the paradox between the principle of entropy, as a general tendency of the physical universe towards disorder, and the contrasting view of man’s and nature’s endeavouring for order. Arnheim directly addresses the question formulated by the mathematical physicist and philosopher of science Lancelot L. Whyte (Whyte 1965 cited in Arnheim 1974b, p. 10): “What is the relation of the two cosmic tendencies: towards mechanical disorder (entropy principle) and towards geometrical order (in crystals, molecules, organisms, etc.)?”. Arnheim approached this conflict from a *Gestaltian* point of view examining the notions of information and entropy against the backdrop of structure and balance,

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of chance. What appears in Flusser as a contradiction, or perhaps paradox, is that moving towards an information criticism of arts would be the equivalent to embrace the role of aesthetic functionaries of the apparatus.

suggesting a grasping of the entropy principle that is different from the conventional idea of dissipation or degradation of energy. He argued that the entropy principle, at least from the point of view of works of art, can be seen as a “cosmic order” towards the “simplest, most balanced structure available to a system”. This idea was in agreement with the “Law of Dynamic Direction”, which he borrowed from the German psychologist Wolfgang Köhler, a key figure, together with Max Wertheimer and Kurt Koffka, in the development of *Gestalt* psychology.

Arnheim opens his book with the following statement:

Order is a necessary condition for anything the human mind is to understand. Arrangements such as the layout of a city or building, a set of tools, a display of merchandise, the verbal exposition of facts or ideas, or a painting or piece of music are called orderly when an observer or listener can grasp their overall structure and the ramification of the structure in some detail. Order makes it possible to focus on what is alike and what is different, what belongs together and what is segregated. When nothing superfluous is included and nothing indispensable left out, one can understand the interrelation of the whole and its parts, as well as the hierarchic scale of importance and power by which some structural features are dominant, others subordinate. (Arnheim 1974b, p. 1)

The orderly disposition of a structure, be it a machine or a natural organism, is a necessary condition for its well functioning. An organised mechanism reflects the coherent operation of its constituting parts. Order and survival are correlated, “the impulse to produce orderly arrangements is inbred by evolution” (Arnheim 1974b, p. 3). A living organism epitomises the striving against entropy and death and the human mind expresses such a goal through the process of invention, art being one of the most prominent.

Experiments in perception have observed the tendency of the human mind to organise visual patterns in the simplest available structure, which suggests, according to Arnheim, that such “activities in the brain have to be field processes because only when the forces constituting a process are sufficiently free to interact can a pattern organise itself spontaneously according to the structure prevailing in the whole” (Arnheim 1974b, p. 4). The figures below (see fig. 5) exemplifies the case in which a combined structure of a

square and a circle is readily apprehended, in contrast to a different set of shapes in which one sees separate unities. Instead of the sum of sub-units, the human brain perceives structures in which parts and wholes are correlated.

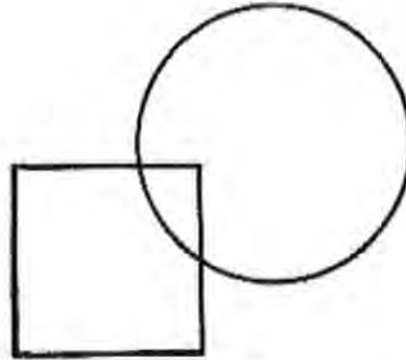


Figure 2a.

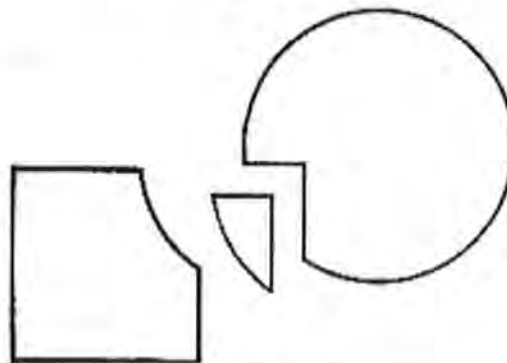


Figure 2b.

Figure 5: Arnheim's example of a square and circle. Source: (Arnheim 1974b, p. 4).

Another point to consider is that the experience of order is never limited to the perception of what is explicitly apparent in an object or event.

Rather, the perceivable order tends to be manifested and understood as a reflection of an underlying order, whether physical, social, or cognitive. (...) Since outer order so often represents inner or functional order, orderly form must not be evaluated by itself, that is, apart from its relation to the organization it signifies. (Arnheim 1974b, p. 2)

Therefore, order and meaning are correlated. Order and disorder can be meaningfully associated. As Arnheim exemplifies, a shuffled deck of cards represents an objective state of disorder, although it also means that all players will receive a similar

variety of cards; in other words a homogeneous distribution (Arnheim 1974b, p. 16). The notion of order and disorder will depend whether one looks into independent parts or the interdependency between part and whole. Order and disorder is observer dependent<sup>30</sup>.

Nevertheless, this level of ambiguity in the concept of order and disorder is not taken into account in the study of thermodynamics. The Second Law of Thermodynamics states that “the material world moves from orderly states to an ever-increasing disorder and that the final situation of the universe will be one of maximal disorder” (Arnheim 1974b, p. 7), defining entropy as “the measure of the degree of disorder in a system” (Arnheim 1974b, p. 8). However, for the gestalt theorist disorder “is not the absence of all order but rather the clash of uncoordinated orders” (Arnheim 1966, pp. 123-135).

The physicist overlooks a possible orderliness in given random distribution (such as in the case of the shuffled deck of cards) because “the probability statistics of the entropy principle is no more descriptive of structure than a thermometer is of the nature of heat” (Arnheim 1974b, p. 14); the physicist does not consider structure. As Max Planck has stated (Planck [1915] 1998 cited in Arnheim 1974b, p. 14), pure thermodynamics “knows nothing of an atomic structure and regards all substances as absolutely continuous” (*Ibid.*). The physicist approaches entropy and disorder considering that “the single elements, with which the statistical approach operates, behave in complete independence from one another” (Max Planck cited in Arnheim 1974b, pp. 14-15), therefore the “entropy principle defines order simply as an improbable arrangement of elements, regardless of whether the macro-shape of this arrangement is beautifully structured or most arbitrarily deformed; and it calls disorder the dissolution of such an improbable arrangement” (Arnheim 1974b, p. 15). In turn, as Arnheim noted, the information theorist will do exactly the opposite as his

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<sup>30</sup> A similar example is given by the cyberneticist W. Ross Ashby (1962). He uses the example of a hive of bees, of which one external observer may see organisation in the interactions of thousands of bee parts, whereas another may just see a chaotic trajectory of the whole group.

object of inquiry “is an individual sequence or some other arrangement of items reduced to such a sequence. He investigates the probability of its occurrence by establishing the number of possible sequences, one of which is the present one” (Arnheim 1974b, p. 19).

What is common in both approaches, Arnheim identifies, is that both the information and entropy theorist neglect structure, therefore stressing a fundamental discrepancy between aesthetic and scientific principles. This is why the criteria of information or entropy alone are not enough for the evaluation of aesthetic structures. The entropy theorist’s main concern is the global macro states of a system, its “global form” (*Ibid.*, p. 21) but not its structure. He is not interested in what happens in between two different entropic states of an examined system. As Arnheim puts it, “the physics of entropy tends to consider only the initial and the final state of a process, not the dynamic events leading from the one to the other” (Arnheim 1974b, pp. 26-27). Arnheim reinforces that:

When a system is considered in two different states, the difference in volume or in any other property, between the two states, depends solely upon those states themselves and not upon the manner in which the system may pass from one state to the other. (...) Thermodynamics exhibits no curiosity; certain things are poured into its hopper, certain others emerge according to the laws of the machine, no cognizance being taken of the mechanism of the process or of the nature and character of the various molecular species concerned. (Lewis and Randall 1923 cited in Arnheim 1974, p. 27).

Here the connection with Claude Shannon’s approach<sup>31</sup> to solve the problem of information transmission is quite evident, as the structural meaning of the content being transmitted is not relevant. On the other hand, the gestalt theorist pays much attention to these transitions, in the gray zone between states. He/she cannot afford the lack of curiosity of the thermodynamic scientist. The reasoning why this is important will now be unpacked.

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<sup>31</sup> This refers to the theoretical model of communication developed by the American electronic engineer and mathematician Claude Shannon. This will be discussed further in the section “Information meaning and aesthetics”.



For the gestalt theorist, order is a property of structure. In a structured world the probability of an event occurring or changing, such as the movement of a line in a artist drawing or the course of an airplane, can be derived from the understanding of the structure (Arnheim 1974b, p. 16), the mechanism which transform parts into wholes meaningfully, not simply by statistical probability. Yet, Arnheim reiterates that

(...) orderliness by itself is not sufficient to account for the nature of organized systems in general or for those created by man in particular. Mere orderliness leads to increasing impoverishment and finally to the lowest possible level of structure, no longer clearly distinguishable from chaos, which is the absence of order. A counterprinciple is needed, to which orderliness is secondary. It must supply what is to be ordered. I described this counterprinciple as the anabolic creation of a structural theme, which establishes "what the thing is about," be it a crystal or a solar system, a society or a machine, a statement of thoughts or a work of art. (Arnheim 1974b, pp. 48-49)

This is the reason why Arnheim opposed the theory of "Aesthetic Measure" developed by the American mathematician George David Birkhoff (1933), who worked in his research statistical methods in order to derive a quantifiable analysis of a work of art. For Arnheim, the aim of Birkhoff was just the measure of order, resulting from the relation between order and complexity (Arnheim 1974b, p. 51)<sup>32</sup>.

The level of complexity of a work of art, if "measured", will be given not by the level of information it carries but by how this information affects the relation between structure and order, or, more precisely, structure and equilibrium. According to Arnheim, the vital impulse towards equilibrium, true "for the symmetries of crystals as well as those of flowers or animal bodies" (*Ibid.*, p. 7), not excluding the human mind, is natural in the mental and physical activities of man's organic and inorganic universe. Such a striving towards balance is the result of physical and psychological forces acting under "field conditions" (*Ibid.*, pp. 6-7). One of the standing points of the present thesis is that the concept of field becomes a fundamental principle for the analysis of works of art and the

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<sup>32</sup> The idea of information aesthetics will be analysed on the section "Information, meaning and aesthetics".

creative process in the information age. In works of art, the concept of information and meaning forms an integral whole.

*Gestalt* is a German word that is usually translated as meaning “shape”, “form” or “figure”, however, the original meaning of the word *Gestalt* is difficult to grasp out of its idiomatic context. That is why *Gestalt* is always used as a German word without translations. *Gestalt* derives from the verb *gestalten*, which means: “to give shape or significant structure to” (Ginger et al. 2007, p. 1), therefore, *Gestalt*, “is a shape or figure, which has *structure* and *meaning*” (*Ibid.*). Order and structure are interrelated meaningfully, and that is why, unlike the scientist, the artist must to look into the intermediary zone where a gestalt of entropy and information, structure and equilibrium, takes place.

According to Arnheim, structure and equilibrium constitutes the two major forces towards form. In part II of this study the section “Form as a diagram of forces” will examine how these two vectors become dynamical components in the morphology of works of art after art practice shifted from a “formalist modernist aesthetic” (Ascott 1980), predominantly focused on the visual/plastic arts of objects, into a behaviourist aesthetic of interactive arts (Ascott 1966; 1967; Ascott [1966-7] 2003a).

### **1.5.2 Taking the observer into account**

The notion of information and entropy may guide the artist in the darkness of the apparatus, but the production of relevant, non redundant information through works of art is the result of a chaotic process to be tested and implemented by trial and error, not by

automatism or regulated by statistical premises<sup>33</sup>. It must be observed in context and fundamentally intuited. In that sense, the idea of an information criticism for art points to a paradox. To invest in this sort of mechanistic critique would be equivalent to transform art criticism in another form of apparatus (the kind we have been criticising). It would mean to feed the apparatus with a pre-text for the analysis of works of art; programming a system with an analytical model able to judge statistically and automatically works of art. It would be the equivalent to stepping towards closure, giving up from one of our most valued chances of freedom – the power to experience what art is or what it could be. Even if in terms of information theory the logic behind such a model is attractive, it would not be applicable in practice unless fundamental changes were implemented, however, for several reasons that will be addressed below, problems will still persist.

To tackle the issue of making “quantifying art criticism” feasible, which would involve making the “objective and subjective meaning of ‘new’ coincide”, as proposed by Flusser<sup>34</sup>, it would be necessary either to elevate the functional aspect of the apparatus to a subjective capacity – in other words, to create a sentient machine (AI agenda) – or to filter subjectivity from the human apparatus<sup>35</sup>. There is also another reason to believe this shift is

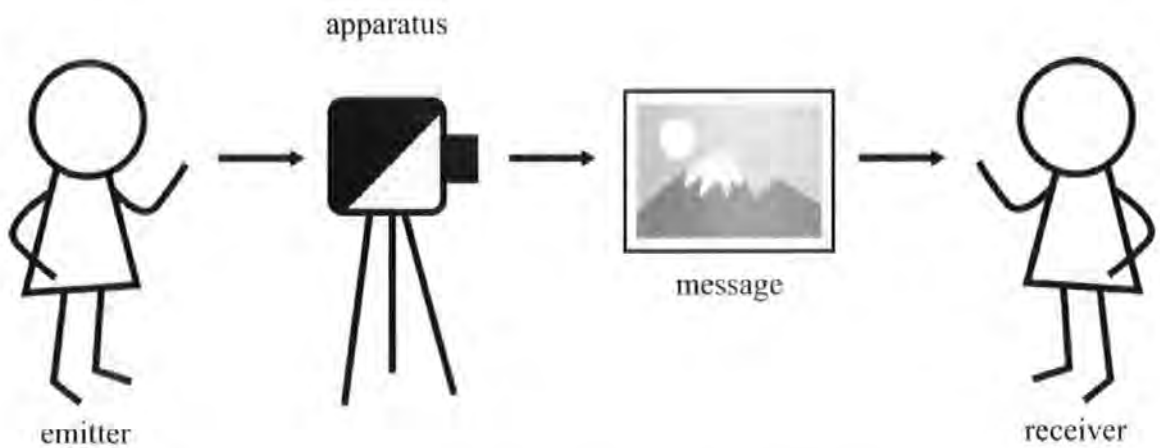
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<sup>33</sup> Even in the case of software art, generative art or using A.I or A.L as the basis for creations of artworks, this thesis understands that it is not the algorithm that qualifies the work as art, but its inclusion or exploration within a given systemic context. It is true that in the last decades the concept of art has undertaken deep transformation and it is not possible to ignore the shift in attention from object to processes to dynamic network systems. New art practices, even new curatorial models (Krysa 2008), have become “more widely distributed between multiple agents including technological networks and software” (*Ibid.*). This thesis does not ignore that, but rather it points out that even those practices, engaged in the highest abstract level of software, human intuition, intention and attention cannot be excluded. The qualities of the human are ingrained in what constitutes the so called “operating system of art” (*Ibid.*). It is under that operating system that the entanglement between software, codes, machines and humans may become art, not the other way round. Art has changed its morphology from stable physical objects to immaterial distributed agents, but even the most generative form may only become aesthetically meaningful in the complexity of social relations in which the human being is still the main character.

<sup>34</sup> Cf. section “Playing with information, from *homo faber* to *homo ludens*”

<sup>35</sup> Both options are improbable situations (therefore informative) and somehow equivalents. The danger is not the rising of a sentient machine, but the high probability that we will be leaving more and more of our most essential decisions to a form of intelligence that is not completely ours<sup>35</sup>. The first option is predicted to happen within a few decades (Kurzweil 2005).

not possible in terms of a pure statistical move. If we return to Flusser's basic criteria for his envisioned information-based art criticism, we must consider that habit in psychology corresponds to a pattern in behaviour. This is intrinsic to the mind of the observer, for what becomes habitual or redundant for one might be seen as original or improbable for others. If it is intrinsic to a possible information critique of art, it needs necessarily to include and involve the observer, as well as the artist, in some manner. It is not new. The openness of the work of art and the role of the observer in arts has already been the subject of discussion of many authors (Ascott 1966; 1967; Clark 1980; Eco 1989). However, the observer in Flusser's theory of photography is not actively taking part in the construction of meaning, they are just a passive receiver, the addressee informed/programmed by the apparatus (see fig. 6). It is unidirectional, as in Claude Shannon's (1948) general communication system, and the information is contained in the classical form of an art object, unified and stable, not open to the observer's intervention.



**Figure 6:** Flusser's unidirectional communication system. © 2009, Guto Nóbrega.

Therefore, at this point the discussion has reached the limitations of Flusser's model based on photography. In order to situate the useful notion of apparatus within the context

of contemporaneous issues of art and technology, we need to extend the concept of “apparatus-operator complex” to the analysis of another structural set based on the elements: artist-artwork-observer. The challenge faced by the artist in such a configuration is still the same - the construction of meaning within the constrained context of an “automated, programmed and programming apparatus” (Flusser 1984, p. 59). However, this new kind of complex, which includes the active participation of the observer, opens the problem to new strategies and metaphors.

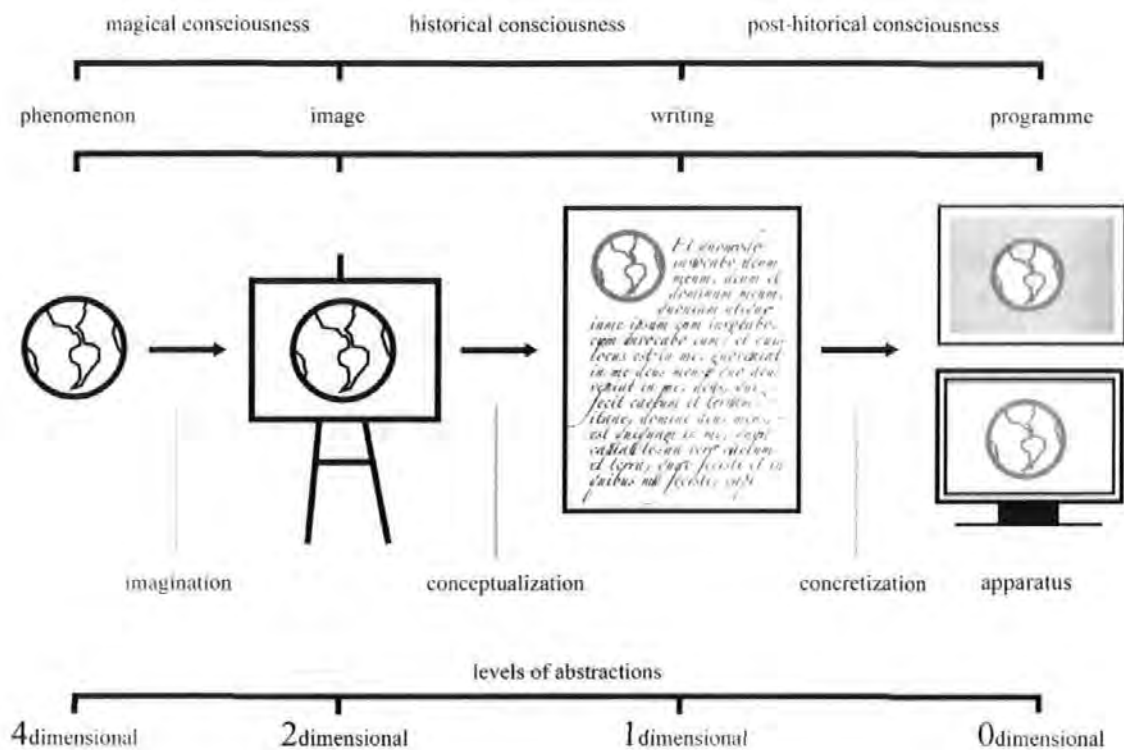
Flusser believed that the experimental photographers are the best operators of the apparatus system as they

(...) seem to know what is happening to them. They are conscious of the fact that image, apparatus, program and information constitute their basic problems. They are aware that they are trying to fetch those situations from out of the apparatus, and to put into the image something which was not inscribed in the apparatus program. They know that they are playing against the apparatus. (Flusser 1984, p. 59)

Thus, Flusser might agree that the experimental artist, along with the observer, would be the best player of the apparatus game. Continuing on, Flusser suggests that the way to generate creative freedom in the apparatus should be to “outwit the stupidity of the apparatus”; “surreptitiously (...) inject human intentions into the apparatus program, (...) to force the apparatus to produce something impossible to see in advance, something improbable, something informative, (...) to hold the apparatus and its products in contempt, to deviate one's attentions from "subjects" in general and to concentrate on information” (Flusser 1984, p. 11). But what does it mean, in practice, to be experimental with the apparatus, especially considering that, above all, the informational nature of the apparatus? How might meaning and information be interrelated within the creation of technologically-assisted art?

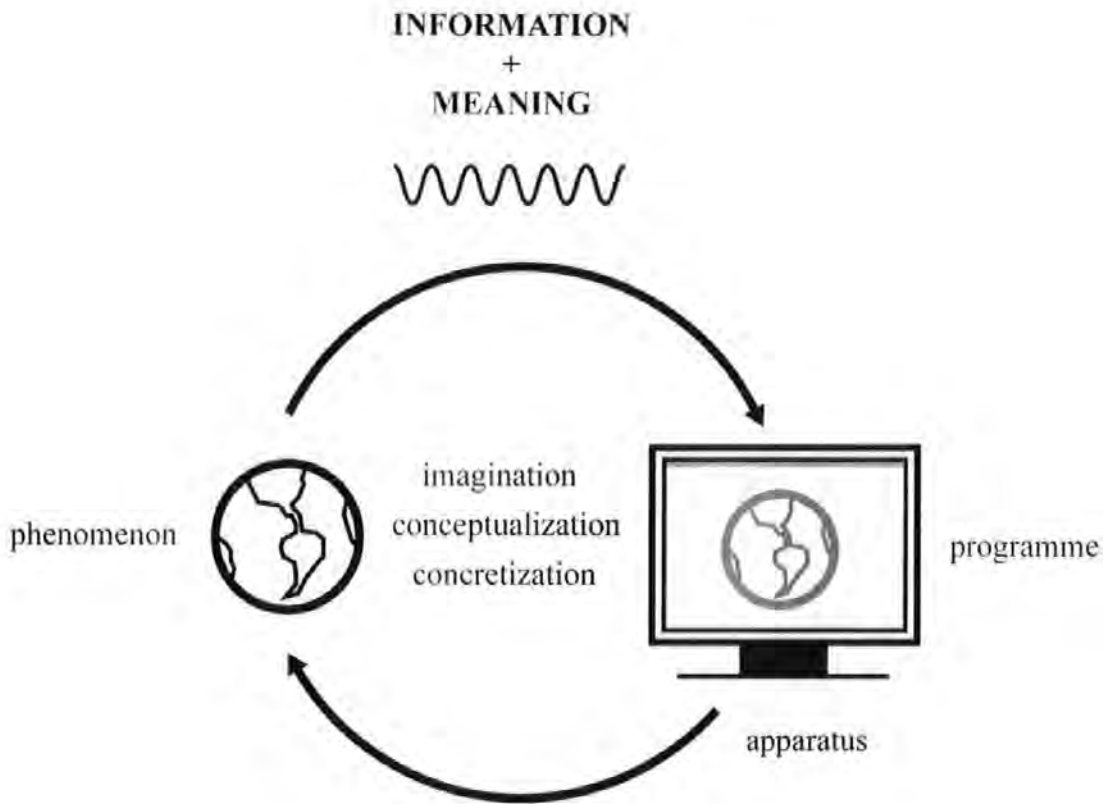
## 1.6 Being experimental. Hacking the apparatus programme

The meaning of being experimental with the apparatus involves consideration to several shifts that take place when the apparatus is thought of in the context of the artist-artwork-observer triad. In such a configuration the observer is no longer the addressee of the apparatus (as the one who contemplates the image produced by the camera-photographer) but becomes, along with the artist, its operator. The artist, in turn, not only plays with the apparatus but also becomes its creator and programmer, feeding inside its system new concepts and models that force the apparatus to behave in a meaningful way. Similar to an experimental photographer, he must break the rules inherent to the apparatus logic to penetrate its “black box”. If the apparatus is separated from natural phenomena by layers of conceptual thinking (images, texts, codes), one might think that bringing the world out there to contaminate its system is a truly experimental possibility. This is the real potential of hybrid systems, to offer a powerful tool for merging different realities. For this the artist must look for new models to be tested with the apparatus, so that improbable imaginary relations could emerge. The outcome of that investment shall not be expected to form informative images of the world, but instead form relational experiences between man, nature and apparatus. The technological imaginary is not the territory, but might be considered as a dynamical map to orient one into the world again, now inhabited by man and technological systems. Taking on board the approach suggested by Flusser, this would correspond to synchronising, in a coherent way, the phenomenological and technological worlds in order to disclose new scenarios and a new imagination. In this context the apparatus should be seen as coherent dynamical structures of information and meaning. As such, Flusser’s ontological approach to technology could be summarised as in the following diagram (see fig. 7):



**Figure 7:** Summary of Flusser's ontological theory of technical image and apparatus. © 2009, Guto Nóbrega.

Based upon this summary, it is possible for this study to propose the following scheme (see fig. 8):



**Figure 8:** Basic scheme for a convoluted structure of information and meaning. © 2009, Guto Nóbrega.

As has been discussed, the power of the apparatus is that it operates by programming and projecting information. This power is on the hands of who brings into the apparatus new codes and models. Flusser stated that “to ask who ‘owns’ an apparatus is to ask the wrong question. The proper question is not who owns a program, but who programs it and who exhausts the program of an apparatus” (Flusser 1984, p. 21). This is why we have called attention to the bringing of new codes and models into the apparatus. However, first it is necessary to define what is meant by bringing new codes.

Behind a computer program there is a pseudocode, based on which the program is designed. Behind the pseudocode there is imagination. The power of the apparatus, as well as its danger, lies in the fact that it implements, in an automatic manner, models of the



world. Its behaviour will depend on which model we bring into it. This points to the fact that the possibilities in a dialogue with the apparatus depend entirely on what kind of model the construction of the apparatus is based upon.

Scientific models are developed within scientific institutions according to a network of very well established validating systems that are based on the falsifiability of observation or physical experiments. Outside this scope there are models that have been refused within the orthodox scientific domain or have not been validated yet, i.e., have not been transformed into efficient mathematical equations. On the other hand, the new codes we are referring to belong to the vast phenomenological world that has no objective visibility as of this moment but, nonetheless, may be accessed intuitively, or experienced under certain circumstances<sup>36</sup>. Therefore, one of the ways we might understand the strategy proposed by Flusser, such as being experimental, would consist of incorporating these non-orthodox models into the apparatus. We might use the state of the art “apparatus” to give us some clue into this journey deep into the heart of the unknown, but we would need in the first instance to be guided by our inner sight, our intuition. It is in this framework in which the hybridisation between natural organisms and machine, science and art, reason and spirit appears to make sense. These points are to be raised in more detail later in the thesis in the discussion of the practice aspects of this research, in which the confluence of natural and artificial organisms are set in the context of a hybrid system, an apparatus structured on the intersection of living and non-living behaviour<sup>37</sup>.

To summarise, playing against the apparatus as an experimental artist, means to not be restrained by the apparatus’s rules (the normative operational mode of the apparatus)

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<sup>36</sup> We are here referring to certain phenomena considered as pseudoscientific due to the lack of orthodox methodology, or perhaps as they are considered religious experiences, which cannot be assessed totally in a scientific basis.

<sup>37</sup> This subject will be fully unfolded through the practice intervention of this thesis.

and to instead play in an inventive manner; using the apparatus structure to reveal what might be concealed or not yet explored within its systemic form. This investigative attitude is exemplified by the work of Nam June Paik, a South Korean-born American artist. In “Magnet TV” (1965) (see fig. 9), a magnet is applied from outside to a TV set in order to alter the electromagnetic flow of electrons within the TV’s cathode ray tube. The result is an endless variation of forms that were never intended by the original apparatus (the TV set), but were activated by the introduction of a new model (the magnet) to re-programme the system.



**Figure 9:** Nam June Paik, “Magnet TV”. Source: (Baigorri 2006)

What is speculated by this thesis is that such an attitude executed by Paik's TV experiment, if applied to more open and complex apparatus, perhaps leads to more powerful experiences.

It is in that sense that the present discussion considers the role of the programmer of apparatuses. To be or not to be a programmer, a dilemma that has been attended to by several theorists of media art (Sommerer and Mignonneau 2003, p. 273; Machado 1997) is equivalent to formulating a wrong question. If algorithms form the "soul of Computer Science" (Science 2008), then programmers would take the role of "Gods". But in the realm of art, computer science might be seen as a subsystem that interacts among other systems, such as the living organic system. Within such a systemic framework a hierarchic view misses the point. Being a programmer and being an artist are functions that may belong to the same individual, as it happens to be true in some cases, but they are strategically different functions. The function of the artist in the dialectical play with the apparatus is to intervene in the system to make it to produce creative and original information. On the other hand, the fundamental function of the programmer is to give conditions to the apparatus system to work efficiently. Both are creative ways of production but do not follow, necessarily, the same agenda<sup>38</sup>. Sometimes these two functions are found in the same individual or group. One clear example of this kind is the collective formed by the two internet artists Joan Heemskerk and Dirk Paesmans. Their collective, known by the label "Jodi" or "Jodi.org", have been exploring the World Wide Web, software art and computer game modification as the basis for their artistic practice (see fig. 10).

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<sup>38</sup> This is one of the main barriers in collaborations between artists and engineers.

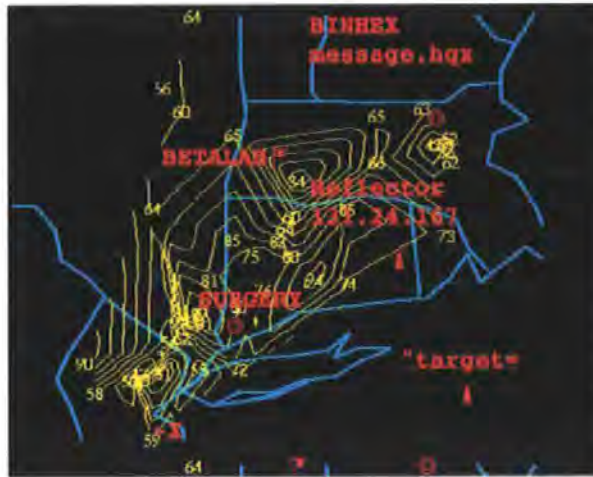


Figure 10: Screen image from the site <http://wwwwwwwww.jodi.org/>.

One of 'Jodi's' most radical pieces is the mimicking of computer glitches and viruses as aesthetic interventions. The political and ludic act of infecting a virus as an artistic activity (which can be easily deactivated by the user after the experience) breaks the magic of the apparatus, forcing it to lose controllability and reveals the power of its programmed system. It is as if, for a moment, the user of that system was allowed to see "through the looking-glass". Hacking the system, altering the apparatus behaviour as an aesthetical intervention, is an example in which the function of the artist and programmer runs together.

The examples provided by the work of 'Jodi' and Paik indicate that the task of being experimental cannot be separated from context and meaning. It is not about playing with information in a simplistic manner but to develop friction between information and meaning. Paik's intervention with "Magnet TV" would not make sense outside the context of counterculture and the art of the 1960s and 1970s, heavily influenced by Marshal McLuhan's aphorism that "the medium is the message". Paik, like many others of his generation, was criticising the passivity of viewers seated before these new furniture-like apparatus receiving unidirectional messages into their homes. Paik argued that "[o]ur job is

a critique of pure television, like Kant" (Paik, cited in Baigorri 2006). But Paik's ultimate goal was not just to develop a critique of television. Unlike many of his contemporaries from the art movement Fluxus, whom were highly engaged in political and social issues (Wolf Wostel for instance), Paik saw the new medium as an opportunity to explore through inventive experimentalism and joy the hidden possibilities of the apparatus. He wanted "to transform it, transcend it, regenerate it and propose new forms of relating to media" (Baigorri 2006). The transcendence and transmutation of the medium was always an ingredient in the artistic alchemy (Duchamp 1957) but the ways to achieve such magic, now aided by contemporary technologies, involve new recipes. Without losing sight of the programmed system of the apparatus, the artist shall play with its rules in order to transcend the implicit limitation of its game. The reason to do that is because in the art of apparatus it is even more necessary to see beyond the causes and effects, avoiding getting trapped in the technocentric discourse. As Flusser reminded us, what makes chess a game is not the checkered board or the chess pieces, but the virtualities within the rules. It is there where information becomes meaningful.

## **1.7 Considerations and directions**

Part I of this thesis, thus far, has extensively examined Flusser's concept of apparatus and now it is possible to summarise how this model intersects with this study. Unlike several authors in the field of art and technology (Couchot 1993; Plaza and Tavares 1998; Kittler 1999; Hansen 2004) his discussion is not set in terms of the innovation and ruptures brought by a digital universe of numerical media. Flusser focuses on the technological imaginary resulting from a chain of symbolic (long term) transformations that

culminated in the advent of the apparatus (which appears in the photographic camera as if in an embryonic state). The main reasoning behind working with the ideas presented by Flusser is that his philosophy was not a philosophy of technical images but a philosophy of technological systems he called apparatuses. Flusser's philosophical goal was to examine the logic behind the complexes he conceived as black boxes. Flusser maintained that to acknowledge the nature of the apparatus as formal, calculated, programmable and programming systems is essential to acquire freedom in contemporary society, especially when artistic practice involves the creation of technical objects. Similarly to Heidegger, Flusser suggested that technology is not a tool for the service of human imagination but is itself a result of a technological imaginary articulated by technique. This is the main point Flusser tried to make clear through the analysis of the apparatus in its most embryonic form, the photographic camera. He showed in his analysis that in cultural terms the notion of apparatus implies a shift in consciousness from work (tools) to information and proposed that the expression of creativity in the universe of apparatuses implies playing experimentally with the codes and models that essentially constitute them. It is in this way that Flusser envisioned works of art emerging out of ordinary form to become relevant information.

It has been argued, however, that the pure probabilistic criterion of information that ignores meaning is not adequate as a model for the analysis and critique of works of art. Supported by Rudolf Arnheim, it has been shown that the concept of information and entropy when applied to works of art cannot ignore structure and meaning.

The next section investigates the influence of Claude Shannon's information theory on aesthetics and points to the weakness of models that have tried to develop and formalise a critical methodology of aesthetics based in processes that are "devoid of subjective interpretation" (Bense 1971, p. 57). Those theories, in general, were rooted on the

unidirectional configuration of “transmitter-receiver-message”, as found in Shannon’s model, and looked for a purely numerical orientated simulation of “aesthetic states” (*Ibid.*). In summary, they were focused on how to optimise aesthetic information. The following paragraphs propose a reorientation of the role of information in aesthetics that is not devoid of meaning. On the contrary, this view takes the role of the artist as structuring open systems in which information is not the variable for aesthetic measure, but the result of the aesthetic experience of meaning.

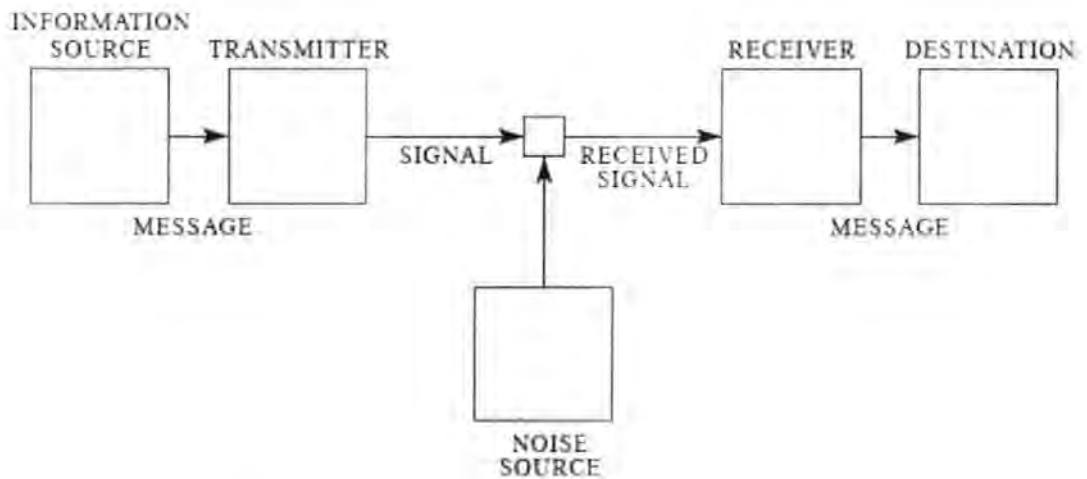
## 2 Works of art as vehicles of aesthetical information

The theoretical model of communication developed by the American electronic engineer and mathematician Claude Shannon situates the formal basis of theories contemporary to the emergence of computer art in the beginning of the 1960s. Shannon was working at the time on the problem of how to optimise the amount of information carried by a communication system (in his case, telephone lines) in relation to noise and distortion.

Drawing upon probability calculus developed by Norbert Wiener, Shannon worked out a “mathematical theory of communication”, which became popularised after its publication in a book co-authored with another mathematician and scientist, Warren Weaver. Central to the Shannon-Weaver model is that meaning was not central to the technical process of communication information, as they determined it is instead dependent on optimising the signal/noise ration quantified in the message (see fig. 11). Shannon defined the problem of communication as being

(...) that of reproducing at one point either exactly or approximately a message selected at another point. Frequently the messages have meaning; that is they refer to or are correlated according to some system with certain physical or conceptual entities. *These semantic aspects of communication are irrelevant to the engineering problem.* The significant aspect is that the actual message is one selected from a set of possible messages. The system must

be designed to operate for each possible selection, not just the one which will actually be chosen since this is unknown at the time of design. (Shannon 1948, italics added)



**Figure 11:** Schematic diagram of a general communication system. Source: (Shannon 1948).

This technical paradigm was adopted as the starting point for the development of a new aesthetic inspired in cybernetic and information theories. For Claudia Giannetti, theoretician and writer in media art<sup>39</sup>, these theories

(...) saw information as the key concept to understanding aesthetic processes, and attempted by means of formalization to create an opposing stance to Kantian and Hegelian tendencies of aesthetic theory. The objective of a formal aesthetic system aimed to deepen not interpretations or value judgments but the system of the work itself, the organization of elements and signs. Every work of art, in fact every artistic expression, was now viewed as a message transmitted by a creative individual (an artist or group of artists), known as the transmitter, to another individual (or group), known as the receiver, over a channel (systems of visual, auditory, and other modes of perception).<sup>40</sup> (...) Viewed from this perspective, the basis of language is reduced to predictable, purpose-oriented, syntactic qualities. Theory in the environs of rational aesthetics therefore evaluates the art object as a system of signs that transports formalizable aesthetic information. (Giannetti 2004a)

The genesis of these adaptations from the fields of logic and physics to aesthetics is linked to the work of the American mathematician George David Birkhoff, who developed

<sup>40</sup> On this respect see the work of Abraham A. Moles, "A abordagem informacional" (Moles 1982).



in his study “Aesthetic Measure” (Birkhoff 1933) a purely statistical method to derive a quantifiable analysis of a work of art. Such a method works in antithesis to the traditional aesthetics based on subjective knowledge. For Birkhoff, information was directly related to complexity; the greater the amount of information in a work of art the more it increases its complexity, therefore the higher is its aesthetic value. In the middle of 1950’s the philosopher, physicist and mathematician Max Bense widened Birkhoff’s theories to include into his formulas the concept of redundancy and entropy derived from the field of information theory. For Bense, works of art should be analysed without consideration for “their effects on observers nor their role in history, or their trading value” (Walther 2000). In Bense’s view it was “not the represented object, but the sign that represents the object is beautiful” (*Ibid.*). Bense believed that the classical formalist concepts of aesthetics, such as proportion, symmetry and harmony, was not enough to account for work of arts, especially when dealing with modern art. Consequently, he systematised basic aesthetical principles in order to develop a theory which could account for a “programming of the beautiful” (Bense cited in Giannetti 2004a). For Claudia Giannetti, (2004a) Bense’s theory of “information aesthetics”<sup>41</sup>

(...) was based on the statistical analysis of art objects and *consigns the subject—the recipient—to the background* by substituting the usage of *adequate rules* in the aesthetic evaluation. (...) Bense distinguished four methods within the aesthetic synthesis: the semiotic, the metric, the statistical, and the topological. The semiotic method is based on the examination of the sign; the metric method, as a sculptural principle, uses parameters such as width, length, number, or ratio in order to define a global structure—the m[a]cro-aesthetic—that takes material form as the gestalt or form of the work; the statistical method generates local structures, or a kind of micro-aesthetic; and the topological method, based on relational principles, is directed at variations of a certain gestalt. (*Ibid.*, italics added)

The weakness of these models, both in Birkhoff’s and Bense’s adaptations, was in part caused by the fact that it was developed from the premises of a unidirectional system

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<sup>41</sup> Delivered in a lecture on “Modern Aesthetics” at the Stuttgart Technological University in 1957, and posteriorly at the “Aesthetica III”,

of transmitter → message → receiver and ignoring the role of the observer in their theories. Despite Bense's efforts in creating a theoretical foundation for aesthetics with a basis in information, and his factual importance in the development of a new form of art based on information processes<sup>42</sup>, his aim for the replacement of traditional aesthetic values based on subjective metaphysical understanding of art with a predominantly logical approach founded in statistical analysis, seemingly replaced one problem by another; it substitutes human subjectivity with mathematical theorems. It objects to human subjectivity in two moves; firstly by upstaging the artist from the process of creation, for through the process he termed generative aesthetic, "a combination of all operations, rules and theorems (...) can be used deliberately to produce aesthetic states (both distributions and configurations) when applied to a set of material elements"<sup>43</sup> (Bense 1971, p. 57), and secondly, by not considering in its equations one of the most important variables in the art equation, the observer<sup>44</sup>. In Bense's examinations, the recipient is consigned to the "background". In his words, "works of art, it might also be said, are a special (that is to say established, not given) class of 'carriers' of the 'aesthetic information'" (*Ibid.*). In other words, works of art

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<sup>42</sup> "Max Bense was the key figure of the Stuttgart School, thought of as an experimental testing ground for rational aesthetics. Influenced by cybernetics and computer art, Bense devoted himself to creating an information theoretical foundation for aesthetics, and to text produced with machines" (Media Art Net 2005).

<sup>43</sup> Even under the argument that the artist is still involved on the process, somehow feeding or programming the variables of the algorithms that will give form to the final piece, he/she is deliberately upstaged by the line of codes and the automatist of the machine that does the work in a sort of "pseudo intuitive way" (Bense 1971, p.60). It is clear, though, that the strategy of stepping back the artist in the support of a more objective machinic intervention is intentional. The work of one of Bense's students, Frieder Nake is illustrative of this case. In "Random Polygon" (13/9/65 Nr. 7), China ink on paper, 1965, 40 x 40 cm, "random processes determine the number of edges on a polygon, their lengths and directions" (Pold 2005). The problem is whether a random process by itself could generate something meaningful or, inverting the question, to what extent are "visualising algorithms and algorithmic processes" meaningful (*Ibid.*)? Does such a process generate relevant aesthetical information or just illustrate what the apparatus is able to do? The recurrent answer to this question is that this process was about "an art that was not directly traceable back to a creative artist expressing himself or his intentions" (*Ibid.*). However, this arises another point: is such an art traceable to the computer's intention, or better saying, purpose?

<sup>44</sup> The observer became one of the main concerns of cyberneticists in what became known as "cybernetics of cybernetics", "meta" or the most often cited "second order cybernetics". This second phase of the development of cybernetic theories, strongly associated with the work of the anthropologists Gregory Bateson and Margaret Mead, the biologist Humberto Maturana, Gordon Pask and Heinz von Foerster, among others, was oriented towards overcoming the determinism of the engineer or the computer scientist in the system's design, in order to consider within the process also the role of the observer in modelling the system (Heylighen 2001).

are viewed as “vehicles of aesthetical information” (Walther 2000). But can “aesthetical information” exist isolated from subjectivity and meaning?

## **2.1 From meaning to information, rethinking the logic**

The meaning of a work of art and the observer are intrinsically linked as meaning depends upon the manner in which the observer intentionally and subjectively approaches the content, even if not, in the case of interactive arts, on the way he/she interferes actively in the constructive process of the message as well. But how might artist and meaning be interrelated in the creative process? Could the observer be substituted in the process by random numbers? Is the improbable orderliness of a work of art merely an effect of “aesthetic measure” (Birkhoff 1933) or does it imply some high level of order intuited by the artist?

It may appear contradictory, based upon the argument thus far, but the work of John Cage, American composer and pioneer of electronic music, will serve as a useful illustration in answering these questions. Cage was notorious for the inclusion of chance in its compositions. His work, along with other artists from the Fluxus movement, is considered as part of the roots of the cultural history of computer art or “algorithmic art as aspects of randomness, indeterminacy and instruction were already present throughout his artistic process prior to his use of computers. In Cage’s work, music compositions were generated from a set of rules or short instructions to be performed by a person or a machine. The similarities appointed between the analogue process of several Fluxus’ artists and computer art are supported by “the way the artist and the human sender take a step back in relation to the expression. The machine creates the expression – the artist like the lab-

coated scientist, become[s] an experimenting operator” (Pold 2005). However, considering Cage’s work we will see that such a comparison fails in recognising some aspects of his process. Whilst in the case of algorithm art the intention and subjectivity of the artist are conveyed to a second plane for the purpose of a machinic performance, in works such as “Music of Changes” by John Cage, the attributes of randomness and programmability are employed in the creative process to free the artwork (the music composition) from the closures of the artistic ego. It is not the artist intention, or even intuition, that is cut off from the process but its controlling mind and desires. Cage would say that:

(...) chance operations are not mysterious sources of "the right answers." They are a means of locating a single one among a multiplicity of answers, and, at the same time, of freeing the ego from its taste and memory, its concern for profit and power, of silencing the ego so that the rest of the world has a chance to enter into the ego's own experience. (Sunday 2009)

The goal in Cage’s operation is to favour the emergence of the work in its own form and truth. As a result of this process the artist becomes perhaps even more connected to the resulting piece as it may reflect an authentic and subtle orderliness to which the artist and the audience are connected as an integral part; an order that might be nonetheless inaccessible to the mind of a non-initiated observer<sup>45</sup>.

This makes further sense if the resonances of Zen Buddhism and *I-Ching* on Cages philosophy and music are considered. Zen Buddhism brought to Cage the awareness to simplicity, disorder, and chance, and the *I-Ching* would become the perfect tool to create his chance-controlled compositions. The *I-Ching* is a Chinese ancient system of cosmology and philosophy. It was used originally by both of the two branches of Chinese philosophy, Confucianism and Taoism, in order to interpret “symbolically all cosmic phenomena and their interrelatedness” (Manuel B. Dy 1998). The fundamental operating principle in the *I-Ching* is the natural process of change that is inherent to life. *I-Ching* means literally “the

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<sup>45</sup> This addresses the fact that many of Cage’s pieces were not understood or accepted by his audience, or even the musicians that were supposed to perform it on the stage.

book of changes” (McCauley 2005, p. 59). The word *I* has three different meanings: “ease and simplicity, change and transformation, and invariability”, it is “a reflection of the universe in miniature” (Ch’u Chai and Winberg Chai cited in Manuel B. Dy 1998). *I-Ching*’s philosophy relies essentially on the primordial unity of the *Tao* and in the dynamic of the complementary opposites *Yin* and *Yang*. It is believed that: “It is through the interactions of these two opposing forces [*Yin* and *Yang*] that change occurs, all events come about, and all things come into being” (McCauley 2005, p. 59).

The chance events tossed by the three coins of *I-Ching* reflect a more subtle order found in the chaos of natural processes, which connects to the inner psychic state of the observer through chance. As stated by Carl Gustav Jung,<sup>46</sup>

(...) it happens that when one throws the three coins, or counts through the forty-nine yarrow stalks, these chance details enter into the picture of the moment of observation and form a part of it – a part that is insignificant to us, yet most meaningful to the Chinese mind. (Jung 1983)

We might say that the *I-Ching* addresses meaning and information in a way that is not accounted for in the Western tradition of knowledge, but in a mind acquainted with Eastern/Asian thinking, as it was in the case of Cage<sup>47</sup>, it seems to make a subtle sense<sup>48</sup>. By using the term meaning there is no reference to the mystical dimension that Western traditions tend to dispose of belief systems such as *I-Ching*, which was not John Cage’s concern. Meaning, in the view presented here, is found in the convergence of chance events articulated by the *I-Ching* system which corroborates to bring insight into a new

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<sup>46</sup> The Swiss psychiatrist Carl Gustav Jung wrote the forward for the German translation of the *I-Ching* by Richard Wilhelm.

<sup>47</sup> Cage had studied Indian philosophy with Gita Sarabhai and of Zen Buddhism with Daisetz T. Suzuki at Columbia University in New York. Having asked Gita Sarabhai “what the purpose of music was in India (...) she replied that her teacher thought that the purpose of music was to quiet the mind, thus making it susceptible to divine influences. Cage was tremendously struck by this” (Solomon 1998)

<sup>48</sup> Again, what might be seen as a collection of insignificant signals by a Western observer may refer to a coherent set of data – or information – for the Eastern cultural perspective, and therefore knowledge.

knowledge. To acknowledge this it is necessary to grasp the difference between Western and Eastern ways of approaching events (information) and meaning.

In the West, we tend to interpret events with a bias towards using a rational perspective. We see linear and consecutive events forming a casual chain to produce the event or moment under observation. (...) The Eastern mind, on the other hand, views the event as a holistic confluence of other events. The configuration may be influenced by chance, but the actual interpretation of the configuration is within the context of meaning. (...) In the West, we might ask how, by cause and effect, did we arrive at the given event under consideration. In the Eastern view, we might ask, given the configuration, which has come about by chance, what does this configuration mean? (McCauley 2005, p. 60)

The diagram bellow illustrates these two interpretations (see fig. 12):

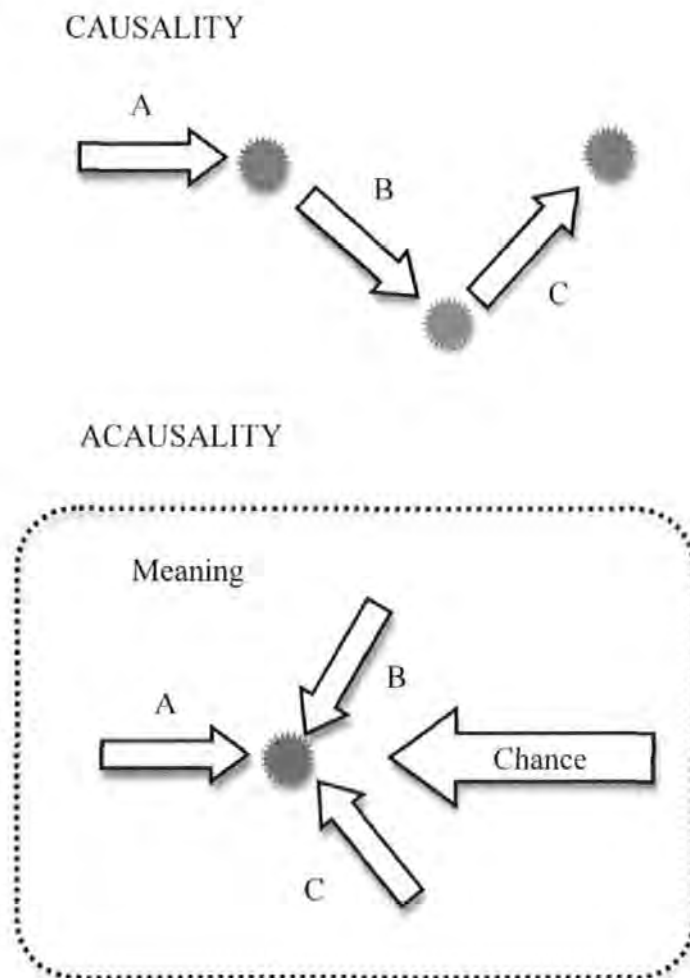


Figure 12: Causal vs. Acausal explanations of an event. Redrawn from McCauley's (2005, p. 60) diagram.

The practice of the I-Ching opens access to an inner wisdom “contained in the unconscious mind or in the higher levels of consciousness” (*Ibid.*, p. 61), free from the ego’s constraints. This freedom was central to Cages’ philosophy and his artistic concerns. It is in this sense this thesis argues that meaning might be intrinsically integrated to information as pointing to a higher level of order and coherence that surpasses<sup>49</sup> the physical system<sup>50</sup>. This is the reason why neither the artist nor the observer should be deprived in any way from the systemic process that constitutes a work of art. They are, along with the artwork, subsystems interlocked by information and meaning. Randomness alone is not enough to produce aesthetic experience, and if art is about experience (Dewey 1979), the work of art might be seen as the ludic play of forces that gives form to a particular state of mind. The newness brought by information technology provides the possibility to play with those forces on-site, affecting and being affected by the artwork.

The dichotomy between information and meaning is the ground of many conflicts and misleadings in the domain of technologically assisted art. This logical separation, instead of conducting the creative process deeper into the realm of a new imagination and consciousness, sometimes obstructs the ludic hybridisation of the human mind and the prosthetic interfaces artists have created to inform the world. It is important though to reiterate the position of this thesis; its concern is not whether it will be possible or not for a machine to create in its own right. Forty years ago, Abraham A. Moles, another key figure in the development of information aesthetic theories, elaborated a series of “fundamental aesthetic attitudes” which, if assigned (codified) to a machine, would rise the performance of that machine to the level of artificial creativity.

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<sup>49</sup> Instead of surpass the word transcend could be used here, however, at this point the metaphysical connotation of this idea is not required.

<sup>50</sup> Physical also considers the immaterial dimension of flow of electrons and data, which may constitute the system in an electromagnetic level. The higher level of order we are referring to manifests on the level of consciousness.

The idea of the machine as creative in its own right is as revolutionary in its own way as the penetration of aleatory methods into scientific thought. (Moles 1971b)

Moles was one of the main visionaries of such a possibility and also one of the first to address some of the fundamental questions regarding this matter:

Will the artists, following the fate of book-keepers and factory workers, also be replaced by machines that make paintings, music and literature? We can safely predict that the artists will not be replaced but their function may be displaced. (...) The negative point about this is what one could describe as “cultural alienation”. The individual, despite the proliferation of art objects [created by machines], will be even further removed from the spontaneous moment of original creation. He will be at a greater distance than ever before from the creative personality responsible for the mass-produced object. (*Ibid.*).

The risk implicated in Moles’ consideration might be related to those raised by Flusser, which claimed that feeding the apparatus with certain models already predicted in its nature (being able to programme and being programmable) just turn human beings into simple apparatus functionaries (STRÖHL 2007). As such, the possible “cultural alienation” anticipated by Moles should not be seen as a consequence of the taking over of the human creativity by machines, but the principal cause of the investment in the automatising of aesthetic functions in machines. The point to be made here is that the impulse to unleashing the power of possible aesthetic sentient machines just conceals the teleological view of machines/computers as intelligent tools for artistic purposes. It is this view that this thesis finds contentious, and it is suggested by this investigation that the relation between technology and art requires a different basis. Technology, in art practice, should be used to investigate the nature of art rather than for the sake of technology or science; it should deepen our understanding of human intuition expressed through creativity. Technology can only help on this task as an ally to dig into the realm of human subjectivity, rather than an opposing force used to filter the human out from the system. This is the main reason for the critique of strategies, such as Bense’s information aesthetics, in which the subjective mind of the artist and the observer are not taken into account. Even when the observer became a central concern in later phases of information aesthetics, it



stressed even further the inadequacies of the approach. As Claudia Giannetti (Giannetti 2004a.) has identified,

In the long term this concept [the nonmeasurable experience of the recipient] led not only to the confirmation of certain weaknesses in information aesthetics, but also to the insight that the application of a theory that explains aesthetic and artistic values solely on the basis of quantifiable and rational criteria comes up against its own methodological borders.

In an interview with, the Austrian scientist and writer Hebert W. Franke, one of Bense's followers, he would admit:

In the meantime it became increasingly evident that art is an intellectual as opposed to material (and thus materially explainable) process; it is a matter of what goes on in the brains of the artist and viewer, and in this respect primarily of perceptual, thought, and behavioral processes. (Franke 2008)

It turned out that despite several efforts in developing a robust theory of information aesthetics their proponents were led, in consequence of their own intrinsic dogmatic logic, to face a paradox:

If one reduces aesthetic questions to a purely rational and numeric evaluation of the work (information as a quantifiable value), then one concedes a cognitive-theoretical value neither to the work itself nor to the aesthetic experience—and herein lies the paradox—and thus renders more difficult the process of truly open communication or, as may be the case, of an exchange of information. (Giannetti 2004a)

In a broader context, this paradox does not limit itself to the issues of information aesthetics but reflects to a great extent the Western dichotomy between mind and body, which echoes on the reductionist agenda of reasoning complexity into measurable theorems. The present study recognises this paradox as a central issue in the creation and reception of works of art aided by information technology. As information becomes a fundamental parameter in the aesthetic process, eventually the problem reduces down to how one evaluates the character of information within the artist-artwork-observer complex.

If in a rationalistic approach information is treated as measurable values for the assessment and generation of works of art, in a systemic approach, information might be considered as an element within an organic repertory of forces acting in resonance to an

observer that sees relations. In such a case, information, instead of a measurable unity for the work of art, might be considered as a “relational concept” (Brier 2008, p. 175) and here the definition of information is approximated to the ideas of the cyberneticist Gregory Bateson. Bateson defined information as “the difference that makes difference” (Bateson [1972] 1987, p. 386). Difference means that information is dependent on the context, the matrix of possibilities that constitutes the artwork. This matrix, set through a process of invention/intuition, is the base from which difference will emerge as a result of the interplay of mental forces of their main subjects: the artist and the observer.

Instead of reducing aesthetic questions to a purely rational and numeric evaluation of works of art, what is central to the thesis is to investigate the systemic role of information within the immaterial, invisible, dynamical field that intercommunicates natural (humans and other living systems) and artificial (machine) organisms. The fundamental question that arises from this view is not *how* to optimise aesthetic information but *what* the aesthetic experience of information and processes means, or even what in fact it could be? The interest of this study is in the consideration as to how information and meaning might be correlated in the context of the artist-artwork-observer complex. The working hypothesis presented here is that the dynamic between information and meaning may be seen as vector forces, which informs the process of creation of the artwork. The argument is that, precisely in the domain of art, information and meaning form an entangled field that can never be reduced to the artwork’s structure, but flow at a meta-level that is unfolded in the experience of the observer and the artist. It may be reasonable at this point to state that in the art domain we witness the occurrence of a phenomenological inversion of the vectors meaning and information. It could be said that meaning gives rise to information and not otherwise.

Deconstructing the information-aesthetic paradox into elementary parts will see the correlation with the complex artist-artwork-observer as follows:

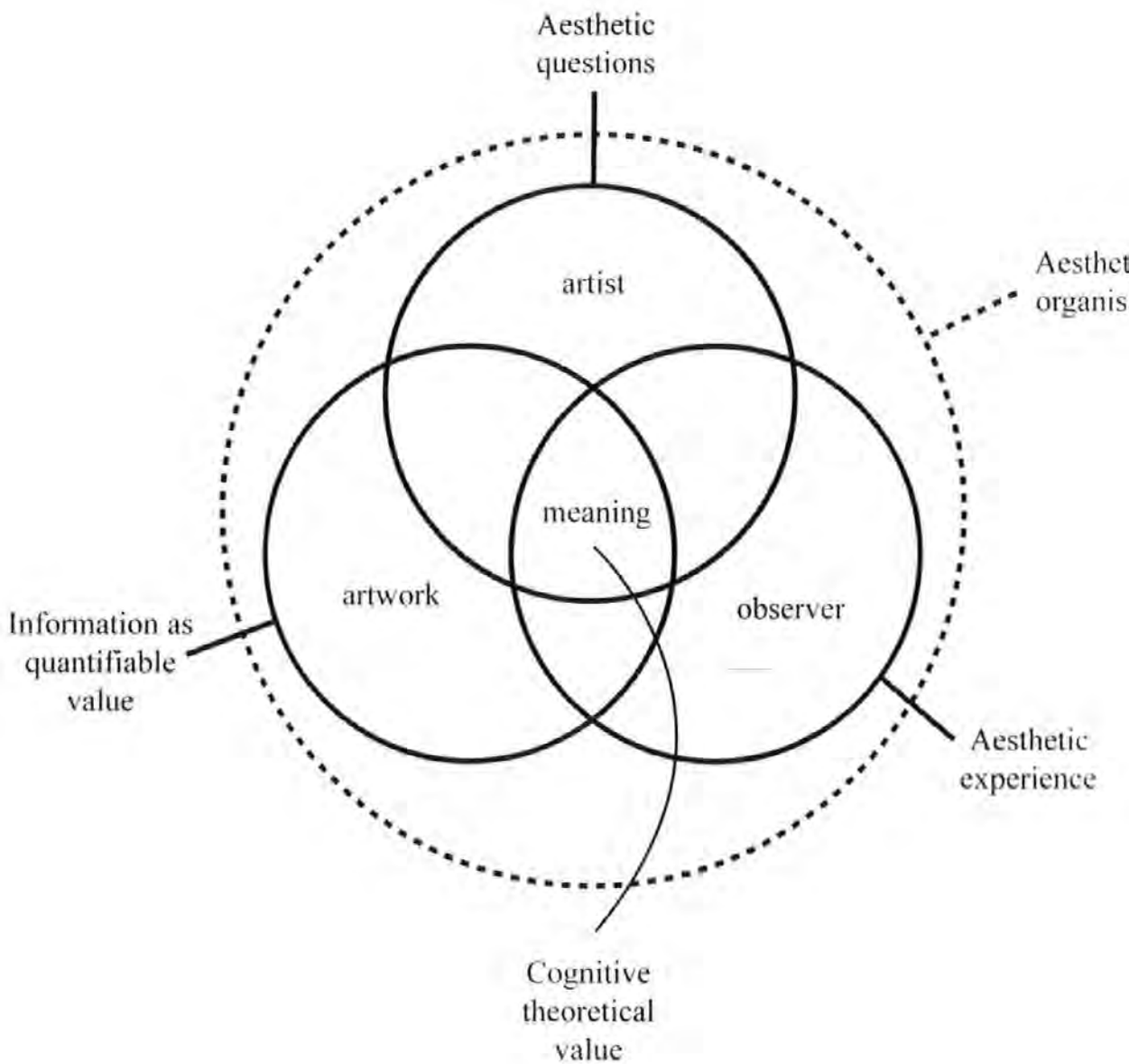
Aesthetic questions → artist

Aesthetic experience → observer

Information as quantifiable value → artwork

Cognitive theoretical value → meaning

Now, if these elements are reorganised into an inter-relational diagram it is possible to visualise the different aspects of their relations (see fig. 13):



**Figure 13:** Interrelational diagram of artist, artwork and observer. © 2009, Guto Nóbrega.

Seen as inter-relational communicating whole, of which the artwork behaves as a dynamic structure of active processes, the artist-artwork-observer complex should never be analysed as independent parts but in the functional context of a aesthetic organic system that behaves, evolves, lives and dies. In consequence of this view, the thesis is led to the question of which methodology should be considered for the analysis of this kind of organism. A reductionist methodology, which frames this system as an aesthetic machine,

or an integrative methodology, in which the dimension of the living organism unfolds beyond its apparent mechanistic structure? This is the subject of Part II of this thesis.

## **PART II: ART**

### **Technical objects, aesthetic organisms and field behaviour**

#### **3 On technological beings**

In this section of the thesis the artist-artwork-observer complex shall be described in the context of a symbiotic relationship between natural and artificial organisms. In order to validate this claim it is necessary to define in which basis the artwork might be considered in biological terms. We need a model that is able to see the artwork (a technical object) not as instrumentation for the creation of an aesthetic experience, but as a technological entity in its own right. A conceptual model allowing for this already exists in the work of the French philosopher and psychologist Gilbert Simondon. For Simondon the technical object shall be understood as an individual. Far from being reduced to utilitarian function, technology, in the Simondon's view, is a process of invention in which the technical object acquires individuation through a process he termed "concretization". Simondon differs from Heidegger in that he does not agree that the essence of technology is nothing technological. For Simondon, the nature of technology lies in its "technicity".

The following paragraphs will examine the mode of existence of technical objects in order to contextualise the process of invention of technologically assisted artwork. The main argument developed within the following sections of this thesis is that the invention

of aesthetic organisms, whose embryonic form is structured in the artist-artwork-observer complex, is the instantiation of a coherent communication system.

### 3.1 Gilbert Simondon brief biography

Gilbert Simondon (1926-1989) is acknowledged in academia by his theory of individuation and philosophy of technology. A former student of philosopher of science Georges Canguilhem, Martial Guérout, and phenomenologist Maurice Merleau-Ponty, Simondon studied at *Ecole Normale Supérieure* and the Sorbonne University in 1944, presenting in 1958 his main Ph.D. thesis, *L'individuation à la lumière des notions de Forme et d'Information* (Individuation in the light of the notions of Form and Information). This work was published in two parts, the first part entitled *L'individu et sa g n se physico-biologique* (Individuation and its physical-biological genesis) in 1964 and the second part, *L'individuation psychique et collective* (Psychic and collective individuation) later on in 1989 (Simondon 1964; 1989). Central to Simondon's thesis was the problem of individuation, which he localised in the passage from pre-individual to individual, a process resulting from what Simondon called "pre-individual fields". Contrary to orthodox approaches that focus on what constitutes individuality, the principle of individuation outlined by Simondon does not consider individual concreteness as the departing point, but thinks of individuation as a process concurrent with the formation of the individual. Gilles Deleuze (2004b, p. 86), whose philosophy was influenced by Simondon's ideas<sup>51</sup> to a great extent, reinforces that "the individual is not just a result of a process, but an *environment of*

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<sup>51</sup> Deleuze's book *Difference and Repetition* (Deleuze 2004a) echoes concepts that are central in Simondon's theories.

individuation”<sup>52</sup>. Gilles Deleuze regarded Simondon’s theory of individuation as being foundational of “a whole philosophy” (Deleuze 2004b). Deleuze commented that:

The new concepts established by Simondon seem to me extremely important; their wealth and originality are striking, when they’re not outright inspiring. What Simondon elaborates here is a whole ontology, according to which Being is never One. As pre-individual, being is more than one — metastable, superposed, simultaneous with itself. As individuated, it is still multiple, because it is "multiphased," "a phase of becoming that will lead to new processes."

Simondon has been studied by authors such as Bruno Latour, Bernard Stiegler, Adrian Makenzie and Mark Hansen and the interest in his work has recently increased considerably.

In 1958 Simondon published a book based on what is known as *these complementaire*, a work in which he developed his theories on individuation further, with a focus on the technical object. This book was released under the title of *Du mode d'existence des objets techniques* (On the mode of existence of technological objects) ([1958] 1989). Immediately after it was published, Simondon’s ideas on individualtion, development and evolution of technology spread out and had a great effect on a broader audience.

Along with much of Simondon’s work, *Du mode d'existence des objets techniques* has received no official English translation. Just a few excerpts and quotes are found in relevant publications such as “Technical Individualization” (Simondon 2007). An excerpt from *Du mode d'existence des objets techniques* is published in Joke Brouwer and Arjen Mulder’s book “Interact or Die!”. Also, translations appeared in papers by Henning Schmidgen (2005) and more recently Marc J. de Vries, the latter of which develops a comparative analysis between Simondon’s philosophy of technical artefacts and the “Dual Nature of Technical Artifacts”, a research program carried out at the Delft University of

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<sup>52</sup> Simondon applies the concept of individuation not only to living organisms but also to technical objects, as developed in his complementary thesis.

Technology in the Netherlands<sup>53</sup>. To this list it also must be added a non-published translation (Simondon [1958] 1980) of the first two parts of Simondon's thesis *Du mode d'existence des objets techniques*. Translated by Ninian Mellamphy and prefaced by John Hart, who has also prefaced the French version, it was developed under the support of the Explorations Program of the Canada Council and is found deposited in the library of the University of Western Ontario<sup>54</sup>.

### 3.2 The technical object and its concretization

The purpose of this study is to attempt to stimulate awareness of the significance of technical objects. Culture has become a system of defense designed to safeguard man from technics. This is the result of the assumption that technical objects contain no human reality. We should like to show that culture fails to take into account that in technical reality there is a human reality, and that, if it is fully to play its role, culture must come to terms with technical entities as part of its body of knowledge and values. Recognition of the modes of existence of technical objects must be the result of philosophic consideration; what philosophy has to achieve in this respect is analogous to what the abolition of slavery achieved in affirming the worth of the individual human being. The opposition established between the cultural and the technical and between man and machine is wrong and has no foundation. What underlies it is mere ignorance or resentment. It uses a mask of facile humanism to blind us to a reality that is full of human striving and rich in natural forces. This reality is the world of technical objects, the mediators between man and nature. (Simondon [1958] 1980, p. 9)

If Flusser examines the essence of technology from an anthropological and phenomenological perspective, in Simondon's project it is the ontological aspect that becomes most prominent. In this sense Simondon's philosophy helps to focus on the emergence of technical objects and their process of invention. In Simondon's view, "the

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<sup>53</sup> Although the most relevant translations are provided in the main body of this text, there is also an English article entitled "The Genesis of the Individual", found in Jonathan Crary & Sanford Kwinter's book "Incorporations" (Simondon 1992). A paper by Adrian Mackenzie, in which he contextualises *Du mode d'existence des objets techniques* in accord to a social-constructivist view of technology, can also be added to the list of English translations. The interest in Simondon's ideas has notably increased of late and non-official translations and discussions about his theories can be accessed on weblogs such as Fractalontology (2008a) or The Pinocchio Theory (2008c).

<sup>54</sup> Quotes of *Du mode d'existence des objets techniques*, unless mentioned, will be translated with base on this English version of the text.

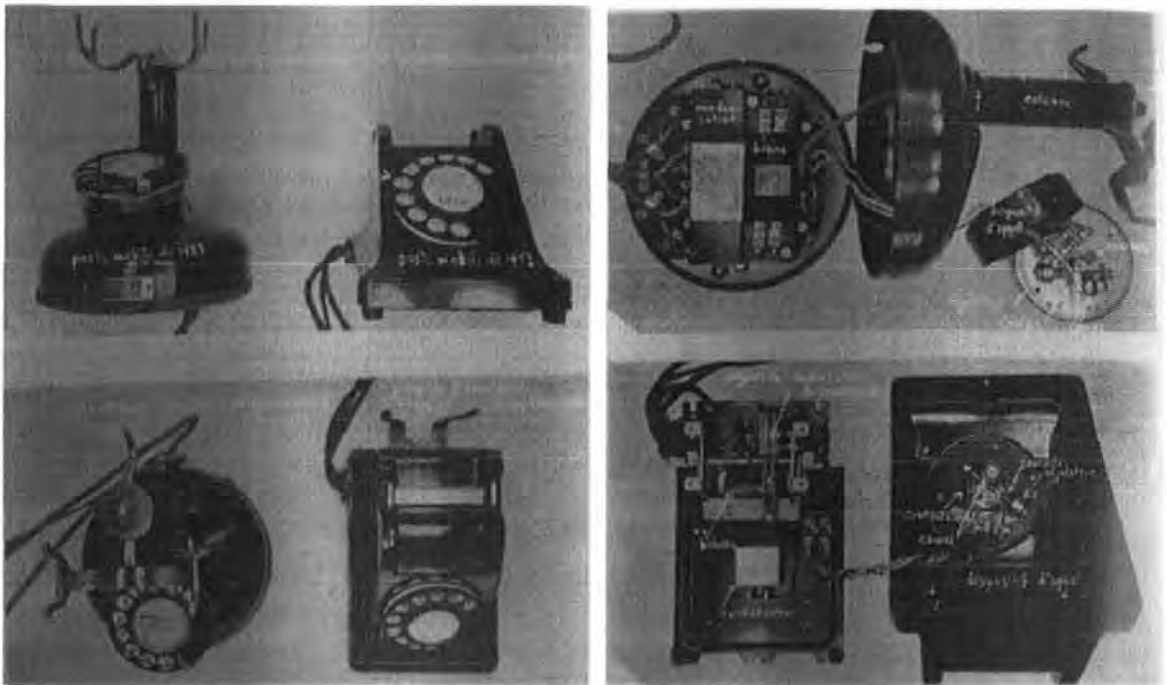


technological object is not this or that thing, given here and now, but that of which there is a genesis" (Simondon [1958] 1980, p. 12). Simondon draws upon *Gestalt* psychology and information theory to put forward the concept of individuation, in which technical objects are set against the backdrop of a key process for technological development: concretization.

Concretization might be understood as an integral process of convergence, in which a given technical structure becomes coherent, meaning its internal parts work in synergy to form an interdependent whole. Mechanically speaking it is the equivalent to saying that the internal organs of a machine are integrated into a whole, the functions of diverse elements work co-ordinately as a global function. When this level of integration is achieved the technical object becomes an individual, however, this does not mean that the technical object has achieved a final state of existence. Rather, individuation is an ongoing process of becoming that develops along with the individual's life until its death. In this sense the evolution of a technical object is similar to that of nature but occurs by different means and logic.

To support his claims Simondon developed a methodology in which the analysis of technical objects, based on his private collection of machine parts (telephones, electronic components, motors, etc.), served as evidence of the concretization process. The engine of an aeroplane may serve as a useful example. If compared with the motor of a car (its predecessor) it could be said the aeroplane motor is in a higher level of concretization, as it does not require a water cooling system. Thus, there is no requirement for any appendix or external element to aid the functioning of the engine in regards to its cooling. Importantly, what Simondon considers a process of concretization does not refer simply to a cosmetic redesign of a technical object. The concretization of a technical object is a result of structural and functional synergies, or in Simondon words, "a convergence of functions within a structural unity" (Simondon [1958] 1980, p. 15). As Henning Schmidgen (2005)

comments, the interest of Simondon “lies in the energetic determinism that is manifested in and outside technical objects”. The case of telephone may provide an interesting illustration of this point. Simondon attended to the fact that certain stages in the evolution of the telephone concretization were only echoed rather than fully instantiated. When the form of the typical telephone was altered so the cradle came nearer to the dial it reflected an external reconfiguration of design without any significant change in the interior of the apparatus. (see fig. 14).



**Figure 14:** In this photograph Simondon shows how the internal structure of the telephone remains the same. Source: (Simondon [1958] 1989)

Following Simondon’s line of reasoning it is possible to add to his argument that a real process of concretization occurred when the electromechanical parts of the early telephone models were replaced by electronic and digital components. Touch-tone models, for

instance, reflected in the external design of the dial the internal transformation of its electronic structure; buttons must be pressed through an electronic keyboard, the telephone became more compact, lighter and further into the future, mobile. These examples are meant to show that there is a logical principle intrinsic to the evolution of technical objects. "The technical being evolves by convergence and by adaptation to itself; it is unified from within according to principle of internal resonance" (Simondon [1958] 1980, p. 13). This principle of logic is based on coherence; the balance of forces that converges technical objects from abstract schemes towards structured unities. It is this intrinsic dynamic of forces that gives the technical object a form of agency and at the same time defines its level of technicity.

The technical object exists, then, as a specific type that is arrived at the end of a convergent series. This series goes from the abstract mode to the concrete mode: it tends towards a state at which the technical being becomes a system that is entirely *coherent* with itself and entirely unified. (Simondon [1958] 1980, p. 16, italics added).

The acknowledgment of such a principle is fundamental for inventors, as that is in essence the mode by which technical objects can be truly created, improved, and experienced. It is at this point in which man and machine may converge in a symbiotic relationship. Machines require man in order to be constructed and man needs to listen to the machines internal coherence in order to make it work in harmony with him/her. It is in this sense that Simondon criticises automatism. For Simondon, the degree of perfection and technicity of machines does not lie in the increasing and improvement of their automatism, as "in order to make a machine automatic, it is necessary to sacrifice many for its functional possibilities and many of its possible uses" (Simondon [1958] 1980, p. 3). Further than this, however, the increasing automatism in machines conceals their "margin of indetermination" (*Ibid.*, p. 4). According to Simondon, it is such a margin of indetermination that "allows for the machine's sensitivity to outside information". A purely

automatic machine is a closed system; on the contrary, a machine with superior technicality is an open machine that incorporates man as the “permanent organizer and as living interpreter of the interrelationships of machines” (*Ibid.*). The metaphor Simondon evokes to illustrate this view is that of an orchestra and its conductor:

Far from being the supervisor of a squad of slaves, man is the permanent organizer of a society of technical objects which need him as much as musicians in an orchestra need a conductor. The conductor can direct his musicians only because, like them, and with a similar intensity, he can interpret the piece of music performed; he determines the tempo of their performance, but as he does so his interpretative decisions are affected by the actual performance of the musicians; in fact, it is through him that the members of the orchestra affect each other’s interpretation; for each of them he is the real, inspiring form of the group’s existence as a group; he is the central focus of interpretation of all of them in relation to each other. This is how man functions as permanent inventor and coordinator of the machines around him. (*Ibid.*).

This passage illustrates how Simondon’s view on machines is not deterministic, but integrative. He sees man among machines, neither controlling them or under their control, but found to be in a cooperative behaviour. Simondon claims this view as he views machines as the crystallisation of human actions into functional structures through a process of perpetual invention, with individuation taking place in machines in a cooperative process with man. It is at this point where the notion of information in Simondon’s theory of technical objects becomes prominent and complementary to the ideas of Flusser described in the previous section of this thesis. Information is not just what the technical object produces but what gives it form. It is what *transforms* the “conductor” and the “musicians” of a coherent communication process into an integrated whole.

### **3.2.1 From abstract to concrete form**

The technicity and individuation of a technical object is the result of a creative process, it does not proceed from pure application of specific scientific knowledge. A

hypothetically perfect technical object should be identified with a “universal scientific knowledge” (Simondon [1958] 1980, p. 32); it should cope with diversity in the course of its technical life, forecasting probable situations in order to function accordingly. As this scientific (abstract) object is never completely known, the technical object “is never completely concrete either” (*Ibid.*). The process of concretization of a technical object corresponds to “narrowing of the gap separating science from technics” (*Ibid.*).

The abstract object is, however, far from constituting a natural system.

“It is a translation into matter of an ensemble of scientific notions and principles that at the most basic level are unconnected one with the other and that are connected only by those their consequences that converge for the production of a looked for result. The primitive technical object is not a physical natural system but a translation of an intellectual system.” (Simondon [1958] 1980, p. 46).

In turn, the concrete technical object is quite the opposite.

“It tends to internal coherence, and towards a closure of the system of causes and effects which operate in circular fashion within its boundaries. Further, it incorporates part of the natural world which intervenes as a condition of its functioning and, thus, becomes part of the system of causes and effects” (*Ibid.*).

By the process of technical concretization the technical object comes to resemble a natural object. But the technical object can at the most only resemble natural objects. Technical objects tend towards concretization, whereas natural living beings are concrete from their beginning. This is the fundamental distinction between technical objects and natural objects<sup>55</sup>; even in the most concrete of technical objects there will remain an amount of abstraction. It may be possible to summarise that concretization is a process of becoming. The concrete technical object is found in between its abstract form, the scheme and the natural organism that is an absolute concrete being.

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<sup>55</sup> Humberto Maturana addresses this issue in a different manner, arguing that living systems, as natural entities, differ from robots because they are autopoietic systems whereas the robots are not. The real difference lies in the fact that living systems are historical systems, whereas robots are “ahistorical”. Both are, though, structure determined systems under dynamic operational coherences. The difference consists mainly in the way coherence is a result of invention in an artificial system whereas in a natural system it is inborn (Maturana 1997).

### 3.2.2 Process of invention

The evolution of technical objects is a result of a constant exchange with the environment. Like a living organism, the technical object influences and is influenced by its environment (Simondon [1958] 1980, p. 61). This environment, at the same time natural and technical, Simondon calls “associated milieu” (*Ibid.*). The associated milieu is by definition “the mediator of the relationship between manufactured technical elements and natural elements with which the technical being functions” (*Ibid.*). The invention of a technical object presupposes a previsionary, imaginatively creative thought, in order to foresee the circular causalities that will only effectively take place in the moment that the object is constituted. The actual object is conditioned by these forces; a field of potentialities which informs the object, already in its abstract level of existence. This exchange of forces that will give birth to the technical object in a given milieu is “acted out by systems of the creative imagination” (*Ibid.*).

In that aspect, Simondon states, the dynamics of thought are similar to that of technical objects as

Mental systems influence each other during invention in the same way as different dynamisms of technical object influence each other in material functioning. The unity of the associated milieu of a technical object has an analogue in the unity of a living thing. (*Ibid.*, p. 62)

Accordingly, Simondon suggested that

We can create technical beings because we have in ourselves an interplay of relations and a matter-form relation which is high analogous to the one we institute in the technical object. (*Ibid.*, p. 66)

The process of invention reflects the coherence of mental schemas in dealing with the issue of matter and form. However, Simondon argued that what determines the dynamic factor in the mental operations in the process of invention is not form in itself but its

exchanges with the “background” (*Ibid.*, p. 63). Drawing on *Gestalt* psychology, Simondon argued that

[t]he background is the harbour for dynamisms, and it is what gives existence to the system of forms. Forms interact not with forms but with the background, which is the system of all forms or, better still, the common reservoir of the tendencies of all forms even before they had separate existence or constituted an explicit system. (*Ibid.*).

What is at stake in Simondon’s argument is the interrelation between virtuality and actuality. The background means potentiality; the source of virtualities and the carrier of information from which the dynamics of form actualise new structures. It is a “pre-individual field, a ‘metastable’ domain composed of disparate virtualities” (Toscano 2007).

Thus,

[i]nvention is a taking into account of the system of actuality by a system of virtualities; it is the creation of a new system from these two. (Simondon [1958] 1980, p. 64)

In that sense we might say that the process of invention of technical objects is the establishing of resonance between coherent states of mental processes and that of the internal dynamics of the technical object being invented. The mental background, as a field of potentiality, plays a fundamental role in the process of invention as well as in the associated milieu in which the technical object comes to life. When a technical object is viewed as an artwork its associated milieu defines the level of physical coupling of that object with the observer; at the same time the field of potentiality, inherited by the object through the process of invention, determines the quality of resonance in the observers mind. This does not mean that the technical object determines the meaning of the artwork. Meaning is opened and remains so whilst the system is able to carry – not a final form – but the dynamics between form and background, which had been intuited in the mind of its inventor. If the relationship is thought of in this manner then it could be said that the technical object is able to project a coherent field of potentialities for its observer.

Technical object and observer become an integrated whole with the associated milieu, and may develop a symbiotic relation as aesthetic organisms.

In order to allow a symbiotic relation to occur the technical object cannot be considered a tool, or simply an application of scientific theorems. What is at stake is not automatism, but the interplay of information and meaning between various interrelational fields; that of the artist's mind, that of the observer's mind and that of the artwork milieu.

At this point it is possible to note another intersection between the work of Simondon and Flusser; the processes of invention. The experimentalism and the function of play becomes the main strategy to unfold the potential synergy of a technical object. "Invention proceeds mainly by evolution of synergies through the process of concretization" (Simondon [1958] 1980, p. xx). The process of concretization, through which the technical object develops its individuation, is the locus of artistic operation. This seems to be the core issue through which the central mechanism of technical beings can be accessed.

#### **4 The aesthetic organism**

In the conclusion of the first part of this thesis, supported by Flusser's concept of apparatus, it was suggested that the artist-artwork-observer complex is an inter-relational communicating whole whose structure should never be analysed as independent parts but in the functional context of an aesthetic organic system. This investigation is looking for a non reductionist model that allows for the analysis of this structure, which encompasses a coupling of natural and artificial forms. Simondon's general theory of technical systems offers a philosophy of technology in which technical beings are seen through the lens of "concretization". Using this view, technical objects are not conceived as totalities but as



process of individuation. This perspective offers enough room to think about technical objects beyond the reductionist view of cause/effect, which might be otherwise thought as mere instrumentation in the context of contemporary art practice. Opposing to this view it is suggested in this thesis, based on Simondon's ideas, that technical objects as artworks are transducers of energy; more specifically they are resonators of coherent fields that interconnect the artist and the audience into an integrated dynamical whole. In order to work this argument out the following section will examine the creation of artworks, focusing on the transition from formalist to "behaviourist aesthetics" (Ascott 1966; 1967). This discussion will start by reviewing the concept of form in light of Rudolf Arnheim's *Gestalt* theory.

#### **4.1 Form as a diagram of forces**

What is an artistic form? In the article "The completeness of physical and artistic form" Rudolf Arnheim (1994, p. 109) claims for an essential difference between the concept of form and shape. Shape is a property of any object, indistinct of it being "physical or mental, natural or artificial, complete or incomplete, accidental or planned" (*Ibid.*). In the strict sense of the concept, Arnheim asserts, "form is an abstraction" (*Ibid.*).

In the way forms are conceived in geometry they "are devoid of forces" (*Ibid.*), however, in the domain of human perception, when forms are correlated to experience, the moves and changes of form becomes a matter of great importance. Drawing on philosophy and modern physics, which identifies mass and energy as correlated concepts ( $e=mc^2$ ), Arnheim argued that a new understanding of form could be delivered from a world view:

which combines bodies and forces. In this more complex view, bodies in and by themselves remain as static as before, but now they are seen as inhabited by forces, forces that move

them and let them act on other bodies. (...) This more unified notion abandons matter as a separate concept and leaves organized energy as the only and sufficient substrate of the universe. What looked like bodies is nothing but an agglomeration of forces. (*Ibid.*)

Therefore, form is primarily a result of this dynamic of forces and the principle by which these forces are organised. What principles are these?

Arnheim drew on the work of one of the founders of *Gestalt* theory, the psychologist Wolfgang Kohler. Kohler developed the hypothesis that the organisation of form is ruled prevalently by a tendency towards equilibrium, an idea that he developed in his "Law of Dynamic Direction" (Köhler 1966)<sup>56</sup> which referred to a general tendency of nature to move towards the simplest available structure and equilibrium. According to Arnheim, nature is governed by such a principle affecting all physical and physiological processes, including the functioning of the human mind. Arnheim asserted that form could be defined as the interactions of two universal forces acting upon macro structures such as those found in works of art. The first force is the tendency towards equilibrium and the second is what Arnheim came to call "structural theme", or, using a term borrowed from the biology of metabolism: anabolic structure<sup>57</sup>. Arnheim summarises the concept of form as "the interaction between equilibrium and structural theme" (Arnheim 1994, p. 111).

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<sup>56</sup> Kohler derived this law from the work of the physicists Pierre Curie and Ernst Mach, who had identified that the approach to equilibrium is "characterized by growing regularity, symmetry, and simplicity in the distribution of the material and the forces within the system" (cited in Arnheim 1994, p.110).

<sup>57</sup> Arnheim defines it as: "[T]he shape-building cosmic for the structure of atoms and molecules, the power to bind and to loose" (Arnheim 1974b; p.31). It could be compared to what in Thermodynamics is referred to as "negative entropy", although Arnheim refused to adopt this term for the reason that, as we have discussed in the section "Order and structure", the entropy principle does not take into account structure. It is not concerned with what occurs in between energy states of a system, therefore it would be wrong to associate anabolic tendency with entropy. One of the critiques Arnheim received was that there is no scientific evidence that the concept of entropy can be literally applied to perception (Carty 1973). However, in this thesis it is possible to understand the value of Arnheim's analogy as a metaphorical appropriation of the concept of entropy that helps the analysis of creative processes when this is conceived as manipulation of energy fields. As Arnheim stated in a passage of his essay, the unconcern for structure in the theory of Thermodynamics does not "imply that no such structure actually exists at the molecular level" (Arnheim 1974b, p.23). Therefore, it is understood that the term "negative entropy" or "negentropy", as introduced by Erwin Schrödinger in his 1943 book "What is life?" (Schrödinger 1967) can be correctly employed taking into account the dynamics of structure.

Arnheim stated that the structural theme could be observed most clearly in the growing of organic forms, such as the bodies of animals and plants. In his support he quoted D'Arcy Thompson whom stated that:

The form, then, of any portion of matter, whether it be living or dead, and the changes of form which are apparent in its movements and in its growth, may in all cases alike be described as due to the action of force. In short, the form of an object is a "diagram of forces". (Thompson 1961; p. 11)

The structural theme of forms reveals itself in nature; for instance, through the rhizomatic movement of a growing plant, visible in the symmetry of its branches and roots. In the arts the structural theme manifests in the striving of a dancer to bring the harmony of form and balance through choreographic movements. The structural theme and equilibrium are essentially related to organic life.

Nevertheless, the play of forces between equilibrium and the structural theme is not only subjected to the performance of motile objects. In "immobile media" (Arnheim 1994, p. 110), such as painting or sculpture, the structural theme is not perceived via the observation of dynamic physical forces in action but through its manifestation in perception. For

perception mirrors the physiological forces of the nervous system. Neither a tree in a painting nor a human body in a sculpture is driven by physical forces, but their visual images are experienced as configurations of forces. (Arnheim 1974a, p. 437; 1994, p. 112)

Arnheim (1974b, p. 34) also reinforced that:

[O]nly in the physical sense is the work of art an object on which a human body operates from the outside. The actual functioning of a painting or piece of music is all mental, and the artist's striving toward orderliness is guided by the perceptual pulls and pushes he observes within the work while shaping it. To this extent, the creative process can be described as self-regulatory.

Another aspect of the structural theme to be highlighted is that it is not a particular characteristic of shapes, mass and visual tensions of a given structure; it is also "embodied in *subject matter*, which adds its own [force] vectors to those offered by shape" (Arnheim 1994, p. 112, italics added). Arnheim provides the example of a Gothic Madonna of the

early fifteen century (see fig. 15). The structural theme is not only a property of the “visual balancing of sizes, distances, directions, curvature, volumes” (Arnheim 1974b, p. 33) – as it can be observed in the confluence of the several large folds in the Virgin’s garment, the majestic vertical symmetry of her body deflected sideways along with the sceptre in counterbalance to the position of the child in her arms – but extends itself far beyond the visual composition. The Madonna is also a reflection of the general context of the mother and child relationship, and in addition the particular theological relation between the Virgin Mary and Christ. Further on in the present discussion, when dealing with the specific context of technologically assisted artwork, it will be argued that the subject matter, as a component of the structural theme, reflects on the artistic choice about the “model”<sup>58</sup> an interactive system (apparatus) is built upon.

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<sup>58</sup> This was explained in greater detail in Part I of the thesis, through the discussion of Flusser.



**Figure 15:** The maddona of Würzburg. Photo Zwicker, Würzburg. Source: (Arnheim 1974b, p. 56).

Arnheim's theory displays that form can be defined as the interaction of two elements: the structural theme and equilibrium. Both these vectors are recognised as resulting from physical and immaterial forces acting upon the work of art as part of its ontological development. The artist's striving towards orderliness resonates the "pulls and pushes" these forces exert upon his/her mind, the artwork being the resulting balance between such a perceptual field and the physical attributes of his/her creation. Arnheim has identified the process of art creation as being self-regulatory, but with a condition:

Only if the shaping of aesthetic objects is viewed as a part of the larger process, namely, the artist's coping with the tasks of life by means of creating his works, can the whole of artistic activity be described as an instance of self-regulation.(Arnheim 1974b, p. 34)

In other words, only when the invisible network of forces which model the form of the artwork in the process of creation – forces that are mirrored and perceived by the artist's internal organic apparatus – are taken into account, not just the artwork itself as a final outcome, can the process of creation be considered as an “instance of self-regulation” (*Ibid.*). Like a living organism striving against death and towards life, the artist and the artwork could be seen like a self-regulating system developing towards a structural balance.

These reasons seem enough to argue that a reviewed concept of form could be extended to the analysis of works of art when these are structured as information communication systems and lose their closure and immobility, so that they behave in interaction with an active observer. The next section will show how this concept of form could be applied to a morphogenetic approach of works of art and to a new theoretical framework for the analysis of the complex artist-artwork-observer in terms of a field relation. However, before this argument is developed it is important to define what is meant by talking about works of art as in the sentence “when they lose their closure and immobility to behave in interaction with an active observer”. This statement reflects the move from “immobile media”, as Arnheim had termed the traditional categories of art such as painting and sculpture, to the creation of technologically-assisted artworks, a form of art fundamentally concerned with the behaviour of things. This is the topic of the next section.

#### **4.2 From “immobile objects” to interactive systems**

“Emergentes”, a recent exhibition at Laboral, *Centro de Arte y Creación Industrial* in Spain, gazed into contemporary artistic productions that have in common the hybridisation between science, technology and arts, which since the last century has taken place in the cultural domain. Although “Emergentes” showcases works produced within or in connection to Latin America, the show is representative of a widespread practice focusing on process-based art in which, with the aid of electronics, informatics, robotics and diverse technological apparatuses, the poetics of the works are developed around the active engagement of the audience with whom the processes are displayed. Seen from the outside, observer, artist and artwork become a functional system whose parts are linked by the evolving flux of actions.

Among several artworks, notable in this exhibition is the work of the artist Rafael Lozano-Hemmer. *Almacén de Corazonadas*<sup>59</sup> is an interactive installation in which visitors are invited to take part by having their heartbeats captured by the artwork interface. The whole piece consists of 88 incandescent light bulbs suspended in a rectangular matrix format in the exhibition space (see fig. 16). Each light bulb blinks at the rate of each individual visitor’s heartbeat. A custom made interface senses the heartbeat of the visitor when he/she holds two metal tubes on the entrance of the installation. This information is sent to the last light bulb in the matrix with immediately starts and keeps blinking in the same frequency of the visitor’s heart. When a new visitor comes to take part in this process a new heartbeat is stored in the matrix of light bulbs, and so on. What is seen through *Almacén de Corazonadas* is a pattern of incandescent light bulbs behaving in resonance to the visitor’s heartbeats. The symbolism of *Almacén de Corazonadas* is manifold; it goes beyond metaphor as each single blinking light bulb represents in fact the heartbeat of a

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<sup>59</sup> *Corazonadas* means messages from the heart. *Almacén de Corazonadas* could be translated as “Messages from the Heart Warehouse” (this author translation).

single individual visitor. The light pattern shown in the installation is full of life. The work is connective, not because the sensor interface provides the technical means to connect functionally the observer to the installation, but because the whole artwork provides a strong sense of connection when it shows one's heartbeat among others behaving in harmony. The observer becomes an integral part of the work, not just momentarily, but enduring in the work's memory. The installation is full of life and joy<sup>60</sup>, and it shows emergent behaviour similar to a living organism.



**Figure 16:** View of *Almacén de Corazonadas* as it was exhibited in “Emergentes” at Laboral. Source: (Lozano-Hemmer 2008).

The work of Lozano-Hemmer falls into the artistic category that has become known as the interactive arts. In this art form the observer, in the past contemplative, is called to engage actively with the construction of the work of art. In this way the work of art can be considered as emergent from the interaction between the artwork (the structure) and its

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<sup>60</sup> These aspects were observed by the author when visiting the installation in Gijón and paying attention to the audience's reaction.



observer<sup>61</sup>. The interaction here must be understood in the way reciprocal actions take place on the part of the artwork as well as of the observer. Thus, the work of art can be said to be emergent, in the closest sense the term “emergence” informs the field of complexity studies (Morin 2006), for it reflects more than the sum of its isolated parts. The artwork is a result of the coherent behaviour of several unities within the system – in the case of *Almacén de Corazonadas*, the light bulbs, the interface, the program, the visitor as well as the artist whom in the first instance envisioned the project. When experiencing the artwork an observer does not see a single piece, but the flux of process as a “temporal medium” (Mariátegui 2007). As the curator of Emergentes, José-Carlos Mariátegui observes, “the process is made visible in the very complexity of its form”.

Although modern information technologies provide powerful means to emancipate the artwork from its past condition as an “immobile medium” to the status of interactive process-based works, this shift should not be seen as technologically contingent. The tendency of modern art in breaking with the formalistic aesthetic approach of the past and moving towards the systemic articulation of behaviour is observable already in the 1960s. During this period artists, philosophers, scientists and politicians demonstrated interest in the science of Cybernetics and General System Theory, grounded on the concept of organisms as open systems, communication networks and information theory, subjects theorised in the writings of, among others, Norbert Wiener, Gordon Pask, Ludwig von Bertalanffy and Claude Shannon.

It is outside the scope of this thesis to give a complete historical account of the precedents, circumstances, moves and theoretical framework involved on the transition from art objects to systems. This has already been the focus of much research by scholars and artists such as Roy Ascott (1966; 1967), Jack Burnham (1968a; 1968b), Niklas

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<sup>61</sup> This differentiation between work of art and artwork will be addressed further in this section.

Luhmann ([1995] 2000) Simon Penny (1999), and Edward Shaken (1998; 2002), among others. What this thesis highlights, for the purpose of the present discussion, is how this move from creation of unified and stable art objects to process-based works informs an organic framework of the work of art as an open system. Such a characteristic, inherited from systemic and cybernetic thinking but still not fully explored, calls for a new theoretical framework for arts in terms of an evolving process of change and coherence and the understanding of the work of art as a dynamical flux of forces. To justify this claim, the thesis will review some of the foundational ideas from the 1960s that mapped and generated the theoretical background related to the new paradigm interactive art. For this matter we shall analyse the ideas of Roy Ascott and Jack Burnham, two significant figures and forerunners in the scenario of telematic arts and system aesthetics, respectively. Also, to reinforce the perspective developed in this section, the thesis will firstly address the work of the Brazilian artist Lygia Clark to show, parallel to cybernetics and systemic concerns, how the shift in modern art towards open systems, behaviour and organic perspective reflected a widespread move, not restricted to European cultural circles.

The work of Lygia Clark<sup>62</sup>, an important figure of the Brazilian Neoconcretism<sup>63</sup>, is particularly relevant to the present discussion due to the fundamental organic character of her artworks (Clark 1980, p. 17), which reflects her search for an “affective” connection between the participant and the artwork. Clark considered that in her creations the artwork should be considered as a type of “container” to be filled with the “breath” of the participant in order that “thought could get alive by the action” (*Ibid.* p. 31). The act of taking part in the artwork makes subject and object become one. The intrinsic relation

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<sup>62</sup> In 2005, the work of Lygia Clark took part in “Open Systems: Rethinking Art c. 1970” held at the Tate Modern gallery in London under the curatorial regency of Donna de Salvo. The exhibition showed a collection of 1970s works which could be labelled under the theoretical framework of system. Among the artist’s that could be found in the exhibition were Mel Bochner, Gilbert & George, Dan Graham, Donald Judd, Sol LeWitt, Richard Long, as well as two Brazilian artists, Cildo Meireles and Hélio Oiticica.

<sup>63</sup> Referent to Neoconcrete art movement in Brazil.

between artwork and participant was the core of many relevant artistic practices on the 1960's and is in the roots of the contemporary forms of technologically assisted interaction.

Despite the influences of a modernist constructivist approach in Clark's previous works, she was much of the time an artist moved by her own strong intuitive impulse, and knew that the mere optical solutions were not enough to resolve her main artistic concern. This concern could be summarised by the following: How to launch the observer inside the dynamical space of the artwork, so that the observer becomes a participative-subject, able to act constitutively on the creation of the artwork (Clark 1980). Her major standpoint was that the work of art does not lie in the object itself but on the experience of the participant as an aesthetic value. *Bichos* (Animal, Beasts) for instance, one of Clark's works created in the 1960s, is a series of geometric structures made of metal plates of different sizes and formats joined together by means of hinges (see fig.17).



**Figure 17:** Lygia Clark *Bicho de Bolso* 1966 - Maria Cristina Burlamaqui Collection Aluminium 12 x 13cm. Source: (Clark 1966)

These modular creatures need to be manipulated by the viewer in order to unfold its numerous structural possibilities.

[Bichos] is a living organism, an artwork essentially active. A total integration, existential, established between him and us. (...) This relationship between artwork and spectator – in the past virtual – becomes affective. (Clark 1980, p. 17)

Despite the simplicity of its material and the absence of any sophisticated technology, *Bichos*, as along with many other of Clark's propositions<sup>64</sup> allows the viewer to get involved in a very elaborate fashion. Her work shows that it is not the complexity of the system that determines the experience of the participant, but it is how the sensible interweave of the object and the subject may engender a distinct phenomenological space. The exquisite relational texture that Clark manipulates through her work, at the time with the aid of very low technology, is analysed on the paragraph of the Brazilian-born artist and writer Simone Osthoff (1997):

The material simplicity of Clark's propositions confronts viewers, however, with very complex issues about art, perception and body/mind relations. (...) Stressing both the present moment and the flux of time, the work is constantly refined by each participant. Clark's apparently simple creations are, in fact, demanding proposition that ask viewers to infuse the work with their lives and energy. Clark was never concerned with self-expression in art, but instead with the possibility of self-discovery, experimentation, invention and transformation.

The participative work of Clark embodies the ideas of the Neoconcrete movement in Brazil. The movement's mentor, the Brazilian poet and art critic Ferreira Gullar de Andrade, put the Neoconcrete Manifest into words in 1959. The Neoconcrete manifest shows clearly that not only was there to be a paradigmatic move in modern Brazilian Art but also that there was a new attitude against reductionism in art. Neo-concretism incited artists to see beyond the objective reality and approach the art object as a "quasi-corpus", a "non-object", so that it could unfold phenomenologically, disclosing the relational space of the aesthetic experience. What follows below is a lengthy excerpt from the manifest:

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<sup>64</sup> This is the way she used to call her works.

We [the neoconcretes] do not conceive of a work of art as a “machine” or as an “object,” but as a “quasi-corpus” (quasi-body), that is to say, something which amounts to more than the sum of its constituent elements; something which analysis may break down into various elements but which can only be understood phenomenologically. We believe that a work of art represents more than the material from which it is made and not because of any extra-terrestrial quality it might have: it represents more because it transcends mechanical relationships (sought for by the Gestalt) to become something tacitly significant (Merleau-Ponty), something new and unique. If we needed a simile for a work of art, we would not find one, therefore, either in the machine or in any objectively perceived object, but in living beings, as Langer and V. Weidlé have said. However, such a comparison would still not be able adequately to express the specific reality of the aesthetic organism.

That is because a work of art does not just occupy a particular place in objective space, but transcends it to become something new that the objective notions of time, space, form, structure, colour, etc. are not sufficient in themselves to explain. The difficulty of using precise terminology to express a world that is not so easily described by such notions did not stop art critics from indiscriminately using words which betray the complexity of works of art. Science and technology had a big influence here, to the extent that today, roles are inverted and certain artists, confused by this terminology, try to use objective notions as a creative method in their art.

Inevitably, artists such as these only get as far as illustrating ideas a priori, because their starting-point already closely proscribes the result. The concrete rationalist artist denies the creativity of intuition and thinks of himself as an objective body in objective space. Artist and spectator are only required to be stimulated or to react: the artist speaks to the eye as an instrument and not to the eye as a human organ capable of interaction with the world; the artist speaks to the eye-machine and not to the eye-body.

It is because a work of art transcends mechanical space that, in it, the notions of cause and effect lose any validity. The notions of time, space, form, colour are so integrated by the very fact that they did not exist beforehand, as notions, as art, that it is impossible to say art could be broken down into its constituent parts. (Andrade 1959)

The Neoconcrete ideas are important in the domain of technologically assisted arts as they form the conceptual roots of an art movement that is focused on the flux of time, process-based, the participative intervention of the observer, body-mind relations and is transactional. This new tendency in modern art, popularised as interactive arts, was foreseen both theoretically and in art practice by Roy Ascott, one of the main figures of the 1960s, who contributed to demarcate the intersection between arts, science and technology<sup>65</sup>.

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<sup>65</sup> The contribution of Gordon Pask (Pask [1968] 1971; Pickering 2000, p.184) to the roots of what became known as interactive arts cannot be ignored, nevertheless, for the matter of specific issues dealt in this thesis (such as field theory and biophotonics) we are going to focus on the work of one of his pupils, Roy Ascott.

Roy Ascott has been a leading outspoken voice in the domain of art, acting prominently in the intersection of art with information and communication technologies termed telematics. Since then he has foreseen and mapped new paths through the intricate network of silicon and carbon we have been building under the auspice of modern information technology. Already in the 1960s, Ascott envisioned changes in modern art, which he addressed under the label “behavioural tendency”. Inspired by the cybernetic vision, Ascott was aware of the evolving tendency of artworks towards non-static, responsive behaviour, which necessarily would involve the observer as an active participant into the artist-artwork system. Computer-based art, in the light of Ascott’s artistic and theoretical perspective, could be seen as an appropriate media for the execution of such an art spirit, the means by which multi-directional communication between the artwork and the world could be put into effect in several levels. It is important to notice that Ascott’s observations were made in a period in which computer art was still in its inception; the majority of works of art that had been technologically assisted were the result of the use of computers as a medium for the creation of images that were digitally programmed (Noll 1971, p. 143). In fact, Ascott’s foresight seemingly reached far beyond the idea of computers as purely a new medium for arts, making his position stand in a quite different front in the arts and technology discourse, one that is not technocentric but is “technoetic”<sup>66</sup>. Art from a technoetic perspective should be understood “as consisting in dynamic ‘networks of minds’, exploiting the connectivity of interactive, telematic media, whose nodal points may have both human and artificial attributes, set in unfolding fields of consciousness” (Ascott 1998). Ascott’s aim was to provide arts and aesthetics with a new framework, based on a cybernetic model, for the values modern art was about to embrace.

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<sup>66</sup> A combination of the Greek words *Techné* + *noetic*, Ascott coined in reference to one of his main concerns: mind and consciousness. *C.f.* (Ascott 1998; [1966-7] 2003b; 2006b)

These values were ingrained in “the ideas of transaction, interplay, net, web, reversibility, association, psychism, multiple meaning, and connectivity” (Ascott 1966; 1967; Ascott [1966-1967] 2003a, p. 183).

In “Behaviourist art and the cybernetic vision” (Ascott 1966; 1967; Ascott [1966-1967] 2003a, p. 183). Roy Ascott articulated a theoretical framework in which the “behavioural tendency in modern art” (*Ibid.*) could be fully developed. His first step was to show that this new tendency in modern art, in contrast with its formalistic aspects – still “centred upon the structuring, or ‘composition’, of facts, of concepts of the essence of things, encapsulated in a factually correct visual field”<sup>67</sup> (Ascott 1966; 1967; Ascott [1966-7] 2003a, p. 110) – was concerned with the behaviour of things in the world; with events, rather than fixed objects. What apparently was at stake in Ascott’s mind was a fully functional model based on the integrative relationship of the artist, artwork and observer in which information is exchanged as part of a dynamic communicative process. In such a model, he stated, “[t]he artist, the artifact, and the spectator are all involved in a more behavioural context”. The goal of such a configuration was

(...) to draw the spectator into active participation in the act of creation; to extend him, via the artifact, the opportunity to become involved in creative behaviour on all levels of experience—physical, emotional, and conceptual. A feedback loop is established, so that the evolution of the artwork/experience is governed by the intimate involvement of the spectator. As the process is open-ended, the spectator now engages in decision-making play.

The technical and theoretical elements of the science of cybernetics were, in Ascott’s view, of similar importance for modern art as optics and geometry were for the

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<sup>67</sup> Here we see a distinct limit between Roy Ascott and Rudolf Arnheim concerning their approach to formalist modernist aesthetic. Whereas Arnheim sees the striving of the artist towards structure and equilibrium as part of a whole self-regulated process that goes beyond the physical limits of the artwork, Ascott sees such a focus on form and the transmission of a defined message to a passive receptor as a limitation inherent from the art of the past. On the contrary, Ascott foresaw a new tendency in modern art – realised effectively in the “postmodern” art (see Ascott’s article “Towards a field theory for postmodernist art” (Ascott 1980) – that reflected a move towards artworks free from past formalist concerns and open to new forms of reception and participation. However, the purpose of the present discussion is to argue that Arnheim and Ascott can be viewed not as opposite views over modernist aesthetic but rather complementary and coherent to the formation of a new aesthetic model (Ascott 1966; 1967; Ascott [1966-7] 2003a, p.110).

Renaissance. Inspired by this model Ascott conceived the idea of a “Behaviourist Art” which will be quoted in length:

Behaviourist art constitutes (...) a retroactive process of human involvement, in which the artifact functions as both matrix and catalyst. As matrix, it is the substance between two sets of behaviours; it exists neither for itself nor by itself. As a catalyst, it triggers changes in the spectator’s total behaviour. Its structure must be adaptive, implicitly or physically, to accommodate the spectator’s responses, in order that the creative evolution of form and idea may take place. The basic principle is feedback. The artifact/observer system furnishes its own controlling energy: a function of an output variable (observer’s response) is to act as an input variable, which introduces more variety into the system and leads to more variety in the output (observer’s experience). This rich interplay derives from what is a self-organising system in which there are two controlling factors: one, the spectator is a self-organising subsystem; the other, the artwork is not usually at present homeostatic. (Ascott 1966; 1967; Ascott [1966-7] 2003a, p. 128)

Consequently,

[t]here is no prior reason why the artifact should not be a self-organising system, an organism, as it were, which derives its initial programme or code from the artist’s creative activity and then evolves its specific artistic identity and function in response to the environments it encounters. (*Ibid.*)

The tendency towards “Behaviourist Art” and the organic framework implicated in his framework should not be considered as an isolated aesthetic aspect of modern art but, as Ascott had already recognised, it was “potentially part of a larger unity, an integral culture, embracing modern science and technology (*Ibid.*).

Similar awareness to these changes is also found in the texts of the American writer on art and technology Jack Burnham, whom saw the new modern moment as a process of transition from an “object-oriented to a system-oriented culture” (1968b). In his influential essay “System Esthetics” (*Ibid.*) Burnham foresaw a new cultural order in which “change emanates, not from things, but from the way things are done”, a new paradigm in which relations, more than things itself, became the new value. Oriented by a systemic thinking he stated:

A systems viewpoint is focused on the creation of stable, on-going relationships between organic and nonorganic systems, be these neighborhoods, industrial complexes, farms, transportation systems, information centers, recreation centers, or any of the other matrices of human activity. All living situations must be treated in the context of a systems hierarchy of values.



He continues,

(...) [t]he specific function of modern didactic art has been to show that art does not reside in material entities, but in relations between people and between people and the components of their environment. (*Ibid.*)

To deal with these changes Burnham proposed an understanding of art far beyond the iconic art object. From a systemic point of view, the artwork should be considered as a sub-system within a broader structure interconnecting several layers of material and immaterial unities. In fact, for Burnham it is the conceptual focus rather than material limits that defines a system. Burnham was influenced by one of the founders of “General System Theory”, the biologist Karl Ludwig von Bertalanffy (1980), whose concept of system derived from “an organismic outlook of the ‘world as a great organization’” (Bertalanffy 1980, p. xxi). From this Burnham observed art as an “adaptive mechanism”, a system of complex interactive elements “comprised of material, energy, and information in various degrees of organization” (Burnham 1968b). According to Burnham the role of the artist under such new circumstances must be levelled to a degree of

a perspectivist considering goals, boundaries, structure, input, output, and related activity inside and outside the system. Where the object almost always has a fixed shape and boundaries, the consistency of a system may be altered in time and space, its behavior determined both by external conditions and its mechanisms of control. (*Ibid.*)

Burnham commented in his book “Beyond Modern Sculpture” (Burnham 1968a, pp. 369-70) that the new modern changes in art respond to a

refocusing of aesthetic awareness (...) on matter-energy information exchanges and away from the invention of solid artefacts. These new systems prompt us not to look at the skin of objects, but at those meaningful relations within and between their visible boundaries.

What is important to observe from a systemic perspective, based on the writings of Ascott and Burnham, is that the manner in which the artwork was considered radically changed from what it is to what it does. The focus shifted from things to relations between things. Ultimately, even if under the influence of techno-scientific thinking, the idea of art as open systems reflected a much broader concern and proposition; it called for a new

consciousness focused on the cosmos as exchanges of information and energy, instead of simple matter.

[T]he cultural obsession with the art object is slowly disappearing and being replaced by what might be called 'systems consciousness'. Actually, this shifts from the direct shaping of matter to a concern for organizing quantities of energy and information. (Burnham 1968a)

The art universe as a micro-cosmos modelled this new attitude towards life in terms of exchanges between the artist, the artwork and the observer.

### 4.3 Metastability and field behaviour

The thesis will now return to the previous discussion of Arnheim's concept of form and look into how his idea intersects with the postmodern model of art based on the systemic organisation of processes and behaviours. This thesis will argue that the link between form and behaviour is grounded in Arnheim's definition of form<sup>68</sup> as the result of interactions between structural theme and equilibrium. To justify this argument, the thesis is required to answer the following question: Where and how do these two ideas take place in such a moment in which the value of the art is not placed on the visual structure of the object but, rather, in the immaterial network of information it conveys as a complete system? The answer suggested by the thesis is that "the structural theme must be conceived dynamically, as a *pattern of forces, not an arrangement of static shapes*" (Arnheim 1974b, p. 33, italics added). Form could be described as a matrix of forces existing somewhere in between the artwork and the perceptual field of the observer. These "complex theme of forces" (*Ibid.*) were made visible in the past through the structural balance of shapes, sizes, volumes, distances or textures, plus the subject matter, which brings form to a painting or

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<sup>68</sup> Cf. the section "Form as a diagram of forces".

sculpture, for instance<sup>69</sup>. In the current configuration of the artwork as a system these forces are not absent at all; they essentially constitute the patterns that interconnect the observer to the experiment, but proceed from a different set of relations. To explain this clearly we need to reconsider form against the shift in artistic creation from closed to open systems.

The artwork as a closed system means that it has achieved its optimum state – the equilibrium of its organising forces – and it is found at “standstill”. From an entropic point of view<sup>70</sup> we could say of the artwork that “the maximum of entropy attainable for the given system of constraints had been reached” (*Ibid.*, p. 33). In artistic terms it means that the artist has organised the structural theme in order to achieve a balance between noise and redundancy so that the maximum amount of information is conveyed through the artwork. Arnheim recognises this phenomenon as a process of self-regulation.

In an open system, as in the case of technologically assisted interactive artworks, several changes take place. Firstly, the processes that were in the past found to be at a “standstill” become metastable, and, in this manner, can be considered a truly self-organising system, as has already been recognised by Roy Ascott. This is so because the behaviourist model envisioned by Ascott furnishes the artwork with a certain capacity, the kind that would provide it with the autonomy to “trigger”, to “catalyse”, being “adaptive”. The metastability of the artwork as a delicate equilibrium is the potential condition for transformation. It is this metastable state which supplies the artwork with a degree of vitality in an organic sense.

Instead of the stagnation created by a state of maximum entropy, the open system of the organism constituted a steady stream of absorbed and expended energy. (Arnheim 1974b)<sup>71</sup>

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<sup>69</sup> Cf. structural theme in the section “Form as a diagram of forces”.

<sup>70</sup> Cf. discussion in the section “Order and structure”.

<sup>71</sup> Cf. Walter Cannon (1963).

It is the capability of the artwork to transform itself in time and to respond accordingly to changes in its milieu that brings to the observer's attention a new phenomenon, that of a two-way dialogue with the system<sup>72</sup> and the openness to interfere with its structural composition. As has been discussed, for Burnham the "new tendency esthetic" (Burnham 1968b, p. 313) of modern art was to "try to make communication between the work of art and the observer a sustained two-way experience" (*Ibid.*). This communication was enabled by providing in the artwork attributes that were, according to Ascott (1966; 1967; 1980), absent in the formalist modern art; namely, the quality of being "connective, inclusive, transactional, associative, referential, interactive". This particular approach to assembling new aesthetic experiences gradually transformed the making of art into situations in which "the general context of the art experience is set by the artist" but "its evolution in any specific sense is unpredictable and depend on the total involvement of the spectator" (Ascott 1966; 1967, p. 111).

It is important to note that the move away from the formalist aesthetic should not be seen as a move away from form. It becomes a misleading interpretation when the concept of form is not fully taken into account and the focus is only on the physical structural unity of the art object. Rather, the move away from formalistic aesthetic reflects the denial of all

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<sup>72</sup> This new feature of the artwork was a direct answer to Wiener cybernetic concern, as stated in the following paragraph: "To indicate the role of the message in man, let us compare human activity with activity of a very different sort; namely, the activity of the little figures which dance on top of a music box. These figures dance in accordance with a pattern, but it is a pattern which is set in advance, and which the past activity of the figures has practically nothing to do with the pattern of their future activity. There is a message, indeed one way but it goes from machinery of the music box to the figures, and stops there. The figures themselves have not a trace of any communication with the outer world, except this one-way stage of communication with the music box. They are blind, deaf, and dumb, and cannot vary their activity in the least from the conventionalized pattern" (Wiener 1950, p.9). Jack Burnham, using the same quote, claimed that the problem of one way communication represented in fact "an inherent defect" in sculpture, automata and even kinetic art (Burnham 1968a, p.312). On the other hand it must be said that this communicative quality of interactive arts, motivated by the aim of creating intelligent feedback systems, appears, paradoxically, also as a problematic symptom when the seeking for higher sophisticated systems concentrates more creative efforts on the functional capacity of the apparatus rather than on the poetics of the system. The poetics, as understood by this research, involves the awareness of subtle, non-material connections between the observer and the artwork. These connections, as we have been discussing, are readable on the interstitial space between the structural theme of the artwork and the perceptual field of the observer.

inertia and opacity inherent to immutable truths, which is mirrored in the factual stability and density of the art object. In a worldview that has changed from the concept of stable solid bodies to uncertain states of energy, artists have consequently shifted their attention to new creative horizons that led them to embrace new ways to fulfil the needs of a new imaginary. If it is viewed historically, the old immobile medium, due its intrinsic characteristics, could not succeed in accomplishing all creative possibilities the new modern mind envisioned. At most, the new imaginary enriched by a modern technological world of wireless transmissions, X-Rays, paradoxes of modern physics and the occult mystical trends of the early twentieth century, could just be alluded to through representation, fixed in the paintings, sculptures and objects of the modern art.

Many modernist artists responded to the invisible energies – physics and/or mystics – giving them their own account. On the essay “Marcel Duchamp’s *The King and Queen Surrounded by Swift Nudes* (1912) and the Invisible World of Electrons”, Linda Henderson (Henderson 1997) observed how modern science and technology influenced Duchamp’s exploration of motion and the invisible. By late 1912, Kupka, a Czech abstract painter, used to conceive his painting as “vehicles for telepathic, vibratory transfer of thought” (Henderson 2002, p. 128) whilst the poet Filippo Tommaso Marinetti “declared the futurists to be the inventors ‘of wireless imagination’” (Henderson 2002, p. 129). Wassily Kandinsky’s treatise “*On the Spiritual in Art*” had the theosophical theories of Madam Blavastky as one of its primary sources (Lucie-Smith 2007). As Henderson recalls, one of the main goals of Kandinsky, also an enthusiastic reader of Rudolf Steiner, Annie Wood Besant, Charles Webster Leadbeater and occult scientists such as William Crookes, Camille Flammarion, Hippolyte Baraduc, and Albert de Rochas, was “to create works of art that would produce a *Klang* or sympathetic vibration in the soul of a viewer”, provoking “a new level of spiritual consciousness” (Henderson 2002, pp. 143-145, italics in the original).

A most evident example of this new modern awareness is the work of Umberto Boccioni, a prominent member of the Futurist movement. In a lecture in 1911 Boccioni declared that “What needs to be painted is not the visible but what has heretofore been held to be invisible, that is, what the clairvoyant painter sees” (Henderson 2002, p. 128). In Boccioni’s vision, futurist painters would possess the power of seeing the invisible, the vibrating ethereal medium, similar to the X-rays and the abilities of the clairvoyance. Such an approach manifested in their work through what Boccioni termed “pictorial dynamism”; “the plastic expression of reality conceived as motion” (Clough 1969, p. 80). “Dynamism is the simultaneous action of the particular and characteristic motion of the object (absolute motion), together with the transformations experienced by the object as result of its displacements in a moving or motionless milieu (relative motion)” (Clough 1969, p. 85). The futurists conceived the concept of “dynamism” in terms of energy, mixing the idea of “Knowledge” as “an inward or ‘centripetal’ tendency of the object which draws the parts together to constitute a whole”, with the concept of “Apparition” as “the manifestation of the diffusive or ‘centrifugal’ tendency which causes the object to resolve itself into emanations whose nature is determined by the energy of surrounding objects” (Clough 1969, p. 84). Through the lens of “dynamism”, reality was considered as “the unending succession of its manifestations” and its pictorial representation as “the unique form of spatial continuity” (*Ibid.*, p. 87), “Dynamism” is a concept derived from the physics of the nineteenth century but, as states the art critic Giorgio Castelfranco, passed through the philosophical “diaphragm” of Henri Bergson (*Ibid.*, p. 213). The Futurists completely displaced their artistic vision from the object to the transcendental world; “beyond all unity of time and place, and beyond the distinction of things”, revealed to their mind through the process of “physical transcendentalism” as pure colour and pure form (*Ibid.*, p. 89). The futurists termed this dynamically created emotion “plastic consciousness” (*Ibid.*).

All these given examples demarcate a transitional phase in modern art that could be recognised in what Ascott classified as “the behavioural analogue”, representing “the analogical restructuring of a behavioural situation” (Ascott [1966-7] 2003a, p. 116). Here, the thesis has attempted to demonstrate that intrinsic to attention to behaviour, there is also attention to the interstitial time and space in which actions take place. It is that space in-between, long considered empty by Western culture, which the new modern technologies have amplified. What is at stake in our contemporary culture is the increasing attention drawn to the invisible and immaterial dimension of our relations, now manifested through the “elliptical zones” or “interval zones” (Domingues 1999 2002b, p. 31) that link body and technology synesthetically. This newfound awareness reflects the decline of old dichotomies such as subject/object, body/mind, observer/observed and space/time. Contemporary focus has been placed on the interpersonal space of our interactions, nowadays conceived as hybrid, “formed by the blurring of borders between physical and digital spaces” (Silva 2004), or in the form of an “aural society” (Susani 2005), bonded by the flow of information, relationships and communication. Similar to the effect old technologies exerted on the modern perception, the new hybrid space, empowered by state of the art telematic technologies, has shaped a new imaginary and led our attention towards the invisible relational space.

Following these tendencies, the attempt at establishing a connection between form and behaviour being developed in this thesis is not an attempt to return to past formalist values, constrained by the purely visual representation of figurative or abstract structures. The argument here is that beyond the formal structure ingrained in the stationary object of art there existed a matrix of forces that gave shape to it. This matrix of forces interconnected the visible structures of the artwork to the physiological organic nervous system of its creator and observer (Arnheim 1974a, p. 437; 1994, p. 112). This diagram of

forces might be conceived in light of the ideas of the French phenomenological philosopher Maurice Merleau-Ponty. In the book “The Structure of Behavior” (Merleau-Ponty 1963, p. 168) Merleau-Ponty describes how the relation between the footballer and the football field appears to him.

For the player in action the football field is not an 'object', that is, the ideal term which can give rise to a multiplicity of perspectival views and remain equivalent under its apparent transformations. It is pervaded with lines of force (the 'yard lines'; those which demarcate the penalty area) and articulated in sectors (for example, the 'openings' between the adversaries) which call for a certain mode of action and which initiate and guide the action as if the player were unaware of it. The field itself is not given to him, but present as the immanent term of his practical intentions; the player becomes one with it and feels the direction of the goal, for example just as immediately as the vertical and horizontal planes of his own body.

Like the football field the artwork appears to both the artist and the observer as a diagram of forces, a field of transformations against which the player/artist/observer “becomes one with”. The aim of this thesis is to demonstrate that this field phenomenon, common and inherent to all creative impulse, independently of the medium or technique involved or the subject addressed, becomes prominent in the work of art based on the systemic organisation of processes and behaviours as a fundamental characteristic of the creative process. This is what Clark was indicating when she observed that the “relationship between artwork and spectator – in the past virtual – becomes affective” (Clark 1980, p. 17). The invisible matrix of forces, which in the traditional arts could only be perceived mentally, finds in the new process-based art a physical resonance. The interaction with the artwork’s structure and behaviour triggers in the observer a potential affective connection. Form, as a “diagram of forces” (Arnheim 1994) reflects the dynamic of the structural theme and equilibrium that in the “modern formalistic approach” were only active during the processes of its creation (artist) or, subsequently, in the mind of the observer. This is why Arnheim had identified the process of art creation as being self-regulatory, only if the “shaping of aesthetic objects is viewed as a part of the larger process, namely, the artist's coping with the tasks of life”



(Arnheim 1974b, p. 34). The art of systems and behaviours fulfil such a condition opening the artistic process to the external observer, which along with the artist acts a co-creator. Moreover, as several authors have already observed (Duchamp 1957; Ascott 1966; 1967; Clark 1980; Plaza 1990), the work of art does not exist in plenitude outside of this co-creative process.

Art comes into being and exists within this dialogic network, both in the domain of interpersonal interactions as well as that between the latter and a context or medium. Art, then, can neither imply a “particular” type of object or of autonomous meaning, nor represent an observer-independent experiential form. (Giannetti 2004b)

The interdependent condition of the complex artist-artwork-observer system provides it with the status of a field phenomenon and figures as one of its most essential characteristics. This new condition mirrors a similar shift that occurred in modern physics which presented a new way of seeing reality. As Katherine Hayles (1984, pp. 9-10) puts it:

In marked contrast to the atomistic Newtonian idea of reality, in which physical objects are discrete and events are capable of occurring independently of one another and the observer, a field view of reality pictures objects, events, and observer as belonging inextricably to the same field; the disposition of each, in this view, is influenced – sometimes dramatically, sometimes subtly, but in every instance – by the disposition of the others.

In 1978 Roy Ascott proposed a “field theory for postmodernist art”, drawing attention to the character of transactional works of art in which a field of “psychic interplay” between the artist and the observer takes place. Ascott suggested that:

Art does not reside in the artwork alone, nor in the activity of the artist alone, but is understood as a field of psychic probability, highly entropic, in which the viewer is actively involved, not in an act of closure in the sense of completing a discrete message from the artist (a passive process) but by interrogating and interacting with the system “artwork” to generate meaning. (Ascott 1980, p. 179)

John Dewey placed emphasis on the distinction between the artwork (art product) and *work* of art, making the field concept of art even more clear. “The first is physical and potential; the latter is active and experienced” (Dewey 1979, p. 162). Dewey continues:

[The work of art] is what the product does, its working (...). When the structure of the object is such that its force interacts happily (but not easily) with the energies that issue from the experience itself; when their mutual affinities and antagonisms work together to

bring about a substance that develops cumulatively and surely (but not too steadily) towards a fulfilling of impulses and tensions, then indeed there is a work of art.

It could be said that the artwork is a set of configurations, a system, the plate of a hologram; the work of art is the experience of its interlinking parts. The artwork is a piece of information, and on the other hand, evoking Gregory Bateson's words, the work of art is "an aggregate of interacting parts or components" (Bateson [1980] 2002, p. 86), a body of ideas, part of a mental system that includes the artist and the observer that is triggered by difference. The work of art, it is argued in this thesis, is the realisation of a coherent, integrative system that might be accessed as a field phenomenon. This phenomenological space that resonates dialogically between the observer, the behaviourist artwork and the artist, will be termed an "integrative field" or, in short, iField.

At this stage it is necessary to bring to attention that the introduction of the field concept is not an attempt to reduce entities to relations, an "ambition in the physics of field" which did not succeed, as Andrew Pickering (2003) has observed. The aim here is to highlight that the field aspect of the work of art is of as much importance as its counterpart, the physical unity<sup>73</sup> (the artwork). Together they form an entangled whole that cannot be experienced separately. More importantly, the field concept opens an unprecedented dimension where the artwork, embodied in a technological apparatus, is set up with models that require a non-reductionist system of analysis<sup>74</sup>.

The following section will examine how, in practice, the dialogue between the structural theme and equilibrium can be seen as a diagram of forces for interactive process-based art, contributing to the ontogenesis of what was earlier defined the aesthetic organism.

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<sup>73</sup> A physical unity is a structure encompassing its material and immaterial parts. Flow of data, light and sound are considered immaterial but no less physical unities. As we have discussed in Simondon, it should be understood as the technical object and its associated milieu.

<sup>74</sup> This will be discussed later in the thesis when dealing with integrative theories of biophotonics and the practical aspect of this research.

#### 4.4 The behaviourist artwork as a hyperorganism

In summary, thus far we have examined art and the creative process in the light of the principles of information and entropy. The artwork is a result, like a living organism, of a striving towards a state of equilibrium and fights against death. Such a state, which was fixed in the structure of the past formalist aesthetic, is found as an active dynamic in the postmodern behaviourist aesthetic. The artwork is organised in a metastable equilibrium, ready to resonate with the observer's presence. The work of art emerges from the entangled field that interconnects the artist, the observer and the artwork in the process of creation. The notion of field is key for the contemporary aesthetic of process-based artworks. It reflects the idea of "form" as a diagram of forces, the dynamics of which were, in the past formalist discourse, limited to the moment of creation by the artist or confined to the perception of the observer. In the postmodern context we shall see form against the new configuration of the artwork in terms of information processing systems. The creative activity, in turn, becomes regulated by a gestalt of behaviours – in reflection of the shift from behaviour of forms to "forms of behaviour", as observed by Ascott ([1967] 2003, p. 157).

With a basis on Arnheim's definition of form as the interactions between structural theme and equilibrium<sup>75</sup>, the thesis will explain how these concepts come into effect according to an integrative field perspective. To proceed with this analysis it is necessary to narrow the scope of the present study to define more specifically the subject of this research. The discussion thus far has specified the transition from "immobile media" to

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<sup>75</sup> See discussion in the section "Form as Diagram of Forces".

artworks based on the dynamical behaviour of processes, however, this requires a little more precision. For process-based art or systems the thesis does not refer to image-centred practices, such as those found in computer graphics, net art, video or animation, often related to the field of “new-media” (Manovich 2004). Neither is the discussion here focusing specifically on electronic/computer music, although these modalities could be somehow systemically integrated to the artwork’s body. The focus of this argument is on practices in which a technical object (in the sense of Simondon’s term), such a robot, a gadget or a system, performs or exhibits some sort of behaviour. In other words, we are concerned with transactional physical systems “undergoing transformations in time” (Benthall 1972, p. 39) that interacts cybernetically between them or with human participants; it is about artworks that share a place with human beings in our physical environment.

Early computer art was notable by a substantial interest in how the computer may be deployed as a creative medium. Early interventions included practicing “computer generated images” that were the result of attempts to recreate paintings of formalist aesthetics with the graphical capabilities of the new medium<sup>76</sup>. An important question during this period was: Could a computer be used to make art? It was not until much later during the 1990s that time-based electronic media, such as High-end Virtual Reality technologies and VRML<sup>77</sup>, brought a layer of interactivity and virtual space to screen-based media. As Simon Penny (1999) observes,

the new media have not necessarily produced new aesthetics. Or perhaps such aesthetics are just invisible to minds used to understanding conventional practice. Take for instance the work of Jeffrey Shaw. Like many of his contemporaries, Shaw moved into digital media from a background in the avant garde of the sixties. (...) Shaw is the quintessential “cyber-formalist”. His works are almost algebraically thorough in their explorations of the modalities of virtual media.

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<sup>76</sup> On this respect see precursors works of A. Michael Noll, Frieder Nake and Georg Nees for instance.

<sup>77</sup> Virtual Reality Modeling Language

And he adds;

Many of the experiments in digital media are formal explorations in which the manipulation of media components [is] the work. In a manner analogous to minimal sculpture, the modalities of the technology become (Burnham 1968a, p. 14) not a vehicle but a substance to be modelled, manipulated and [juxtaposed] with the viewer in various ways. And if the technological combination is the work, then its ability to carry narrative "content" is a secondary issue and somewhat superfluous.

Even with the layer of interactivity, empowered by the use of information technology upon screen-based media, the experience of the observer, the so-called "vuser" (Seaman 2002) or "interactor" (Davies 2003), much of the time remained confined to a virtual three-dimensional space, often set as a simulation of the apparent reality. In cases such as these, the past formalist model of art appears to have just shifted from one surface to another.

The focus of the examination and practice discussed within this thesis is not placed on the screen but converges towards the "substance to be modelled", as identified in Penny's quote. This substance will be treated by the present study, not as a new medium, but as a technical object in the configuration of the aesthetic organism. This will be termed a hyperorganism – a structure that combines a virtual dimension of reality, provided by the agency of information technologies, with the embodiment of an object. The hyperorganism could be thought as part of a lineage from the technical object conceived by Simondon, as it within its process of individuation it encompasses a new dimension provided by telematic resources and networks. It must be considered not an end in itself, but a node, a locus of liaison. Despite the fact that this hyperorganism has a physical presence, it is not to be conceived as a unity, a totality, but a condition, a state of being that is defined by its relational character in network with other beings, artificial and natural, in the world<sup>78</sup>. This hyperorganism has resulted from a third wave of the evolving intersection of art and

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<sup>78</sup> Cf. the concept of "individuation" of technical objects in Gilbert Simondon, section "On technological beings".

technology, characterised by a move away from the screen towards the physical space. This move could be seen as a shift away from simulation to emulation, as suggested by Shawn Brixey and James Coupe (Brixey 2007 cited in Kudla 2008).

The paradigm shift that emulation art suggests is the inevitable result of hybrid art research praxis at the intersection of scientific discovery, informatics and aesthetics, as we seek to understand the universe as an operating system in which we perpetually engage on both a microcosmic and macrocosmic level.

The use of open source platforms, either in the form of hardware or software<sup>79</sup>, as well as the availability of information throughout an interconnected global network, have nourished these new technological organisms. Websites such as “Make magazine”<sup>80</sup> or “Instructables”<sup>81</sup> result from a new culture in which codes, schemes, and processes of invention are made available on the internet and exchanged so that new hyperorganisms emerge from that interconnectivity. Technology has aided the development and sharing of technology. As technology proliferates new relations are produced between people, things and their environment.

#### **4.5 The hyperorganism gestalt**

Having delimited our focus we shall return to our discussion regarding how the concept of structural theme and equilibrium might be linked to the conception of behaviourist artwork. The following discussion will be focused on the artwork as a hyperorganism set against five interrelated aspects of its formation: (1) structure and functionality, (2) subject matter, (3) environment, (4) conceptual model and (5) equilibrium. The diagram bellow (see fig. 18) illustrates these relations.

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<sup>79</sup> For example Arduino, “an open-source physical computing platform based on a simple i/o (input/output) board, and a development environment for writing Arduino software”(Cf. <http://www.arduino.cc/Arduino>)

<sup>80</sup> Cf. <http://makezine.com/>

<sup>81</sup> Cf. <http://www.instructables.com/>

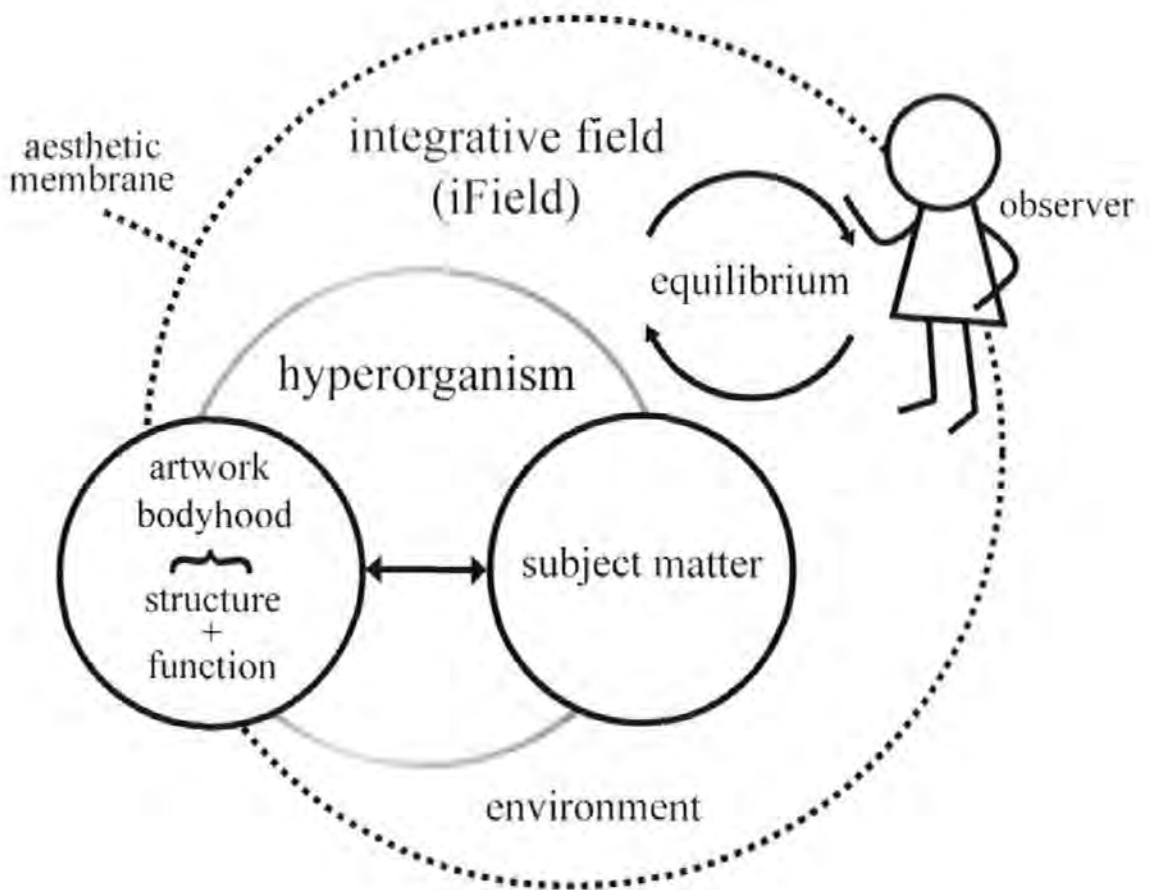


Figure 18: Aesthetic organism structure. © 2009, Guto Nóbrega.

This thesis presents the argument that *structural theme and equilibrium*, seen as part of the diagram of forces that brings perception to form (Arnheim 1974b, 1974a, 1994), can be viewed, in the context of a behaviourist aesthetics (Ascott [1967] 2003, p. 157), as *dynamic vectors of an integrative field*. Originally observed in the body of animals and plants (Thompson 1961, p. 11), the structural theme is also present in behaviourist art, however, with the fundamental difference, in the art context it is the result of a process of invention. Such a characteristic makes it an evolving process highly interlaced with human agency. These ideas will be discussed in the following sub-sections of the thesis and will be supported by an analysis of a selection of artworks and insights developed during the practice aspect of this research. These artworks, which includes a piece developed by the

author of this thesis, were invented by contemporary young artists whose works might be inserted into the category defined as “hyperorganisms”. Rather than analysing the works of renowned artists of art and technology scenarios, it has been decided to analyse, as much as possible, artists near the beginning of their careers with a potentially fresh perspective on the current creative possibilities at the intersection of art, science and technology. In spite of their relative youth, all of the artists present a creative and experimental approach that is consistent with the issues the present study is attempting to deal with. Also, most of the analysis that will follow is based on statements of these young artists.

#### **4.5.1 Structure and functionality**

The technologically assisted art object, or the hyperorganism, is not just an organisation of shapes, but it is a combination of functions. It is thought to perform, to process information and to behave, in certain aspects, similarly to a living organism. Its structure is made of electromechanical parts, organised coherently to cope with certain tasks during its time of existence. Coherence is an important attribute for the life of a living organism and even more so for an artificial one<sup>82</sup>. However, unlike natural living organisms, the life of the hyperorganism is intermittent. It is only brought to life when its artificial system is “on”, when there is energy circulating in its electro-mechanic parts and there is a flow of data in its circuitry. Like any other device, the hyperorganism dies when it is “off” and is reactivated when it is “on”. Nevertheless it provides very particular attributes. The art hyperorganism has memory, a memory that does not reside in its body, but manifests somewhere in the integrative field that links it to the artist and to the

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<sup>82</sup> As being a result of human invention, the functional coherence of technical objects is a factor that must be considered in advance, as has been discussed in the review of Simondon earlier in this part of the thesis.



observer. To be more precise, the life of the art hyperorganism begins in the very moment its scheme is imagined. The body of the hyperorganism keeps a straight relation to its functions, although it is not totally determined by them. As it will be seen, the subject matter, a component of the structural theme, has great effect over the way the hyperorganism behaves, thus directly informing its construction. As it is created to behave in some imagined manner, the function of its parts is considered by the artist beforehand, however, its meaning is not determined at this stage. Meaning, as has been reiterated throughout, is emergent from and within the integrative field and is also dependent on the particular perspective of the observer. The hyperorganism is not to be thought of as a tool or an instrument. The purpose of the hyperorganism's functions is not to produce work, but to inform and absorb information. Its main function as an art object is to exist. This way, the structure of the hyperorganism is totally interrelated to its behaviour and its mode of existence.

For instance, since 1999 the artist Ralf Schreiber has been developing several small experimental artworks that involve kinetic objects, installations and sound. One example of his works, "Living Particles", comprises a series of basic electronic analogue circuits that take the form of miniature robots (see fig. 19, 20). These modules have a peculiar characteristic of being solar powered, which allows them to behave autonomously producing movements and variable sound patterns. Light sensors acting upon their internal oscillators trigger these sounds. The bodies of these little creatures are the result of a collage of electronic components, a mixture of form and function in which the structure and the appearance of the object is conditioned to the functionality of the components and their intrinsic shapes. As Schreiber explains:

Their aesthetic is determined by the functional electronic components. My interest lies not so much in the individual output of [t]his miniature robots but in their interaction with each

other. The focus is on the space, formed by the linked modules and on the developed sculptural and acoustic fields. (Schreiber 2009b)



**Figure 19:** “Solarsoundmodul”. Source: Ralf Schreiber (2009b).

Schreiber’s creations are playful objects. They are to be considered as a collective of artificial organisms whose behaviour, sounds and erratic movements determine its milieu. To an external observer they might appear to be talking to each other in function of their variable sound pattern, which is achieved by their “internal astable switching status”<sup>83</sup> (Schreiber 2009b). Also, the presence of the observer disrupts the contingent balance of the creatures altering the behaviour of the whole system. As has been discussed earlier, the work of art is in a constant metastable equilibrium, always open to the observer’s intervention. This way the observer becomes, to use Schreiber’s words, part of the “sculptural and acoustic field”, a phenomenon that results from “the interactions between equilibrium [now dependent of the observer’s interaction] and the structural theme” (Arnheim 1994, p. 111). Therefore, it could be argued that the overall form of “Living

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<sup>83</sup> Astable state refers to an electric circuit that oscillates spontaneously between unstable states.

Particles” is perceived in the interconnecting field that resonates in the artwork at one extremity and the observer’s body at another.



Figure 20: “Living Particles”. Source: Ralf Schreiber (2009b).

#### 4.5.2 The subject matter

The perception of the structural theme is not restricted to the performance of the artwork; in other words, it is not only a result of its shape and behaviour, but is a property

that encompasses its subject matter. As Arnheim has argued, the subject matter of a work of art “is neither arbitrary nor unimportant. It is exactly correlated with the formal pattern to supply a concrete embodiment of an abstract theme. (...) Neither the formal pattern nor the subject matter is the final content of the work of art. Both are instruments of artistic form. They serve to give body to an invisible universal” (Arnheim 1974a, pp. 460-461). But how does the interrelation between subject matter and the “invisible universal” manifest in the behavioural object of art?

In the past formalist aesthetic the subject matter was expressed as a topic, which the content the artwork addressed through its symbolic forms, be those expression registers of figurative or abstract nature. In the behaviourist artwork, it is suggested, the subject matter should not be considered only in symbolic terms but as a phenomenon manifested in the artwork’s bodyhood<sup>84</sup>. Behavioural art deals with events in which the art object acts in the world<sup>85</sup>; in other words, an event in which, as Guy Brett had already observed in the work of kinetic artists, “the phenomenon of the visual is immersed in the phenomenon of energy” (Brett et al. 2000, p. 9). Through considering the artwork as a system, having as its core a technical object capable of behaviour, it is no longer representing symbolically things and ideas in the world but rather it is presenting itself in the world as having an identity, or as Gilbert Simondon ([1958] 1989) claims, the artwork is an “individual”. As has been argued in this research, the identity of the artwork as a technical object is intrinsic to technologically assisted art and resonates along with the subject matter directly in the aesthetic experience. The subject matter of a behaviourist artwork should not be perceived simply as a topic or theme for the artwork, but as a model expressed through the

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<sup>84</sup> Bodyhood is been used here in resonance to the way this concept appears in Maturana. He claims that “all that occurs in or to a living system is operationally subordinated to the conservation of the manner of living that defines and realizes it in the domain in which it operates as a whole or totality. Or in other words, the *bodyhood* which is where the autopoiesis of the living system in fact occurs (Maturana 1997)

<sup>85</sup> Even if in a totally immaterial manner, or manifested as “no-things”, as Flusser used to call information (Flusser [1993] 1999, p.86)

functionality of the hyperorganism. The significance of speculative models of nature for the artist, even before the rise of information technology, was explored as a curatorial theme in the exhibition “Force Fields. Phase of the Kinetics” curated by Guy Brett<sup>86</sup>. On the exhibition catalogue he stated:

[A]rtists, no less than scientists, make ‘models of the universe’. Their models are arrived at intuitively but are no less valid, no less a form of knowledge. A thread of ‘cosmic speculation’ can be followed in the work of many artists between the loose dates of 1920 and 1980 that this exhibition covers. It is a thread of fascinating intricacy, precisely because the structures that artists have arrived at combine an investigation of reality with an investigation of the aesthetic. It is as if speculation on the structure of the universe, for these artists, is inseparable from a transformation of the formal structures of art, and vice versa, that the formal transformation of art is itself a proposition on the structure of the universe. (Brett et al. 2000; p. 10)

The point attempting to be made here by the research is that in process-based artworks, the dialogue between structure and subject matter resonates directly with their discursive models and general behaviour. In this sense, the environment, as subject matter, becomes of true significance to the behaviourist artwork, as it defines the context in which the artwork performs its discourse and where the dialogue with the artist and the observer takes place. Of equal importance is the model the artwork is based upon. The experimentalism with the apparatus, as we have seen in Flusser, becomes a prominent approach apparent through the subject matter. The speculative incorporation of new models in the program of the apparatus may allow for the exploration of unexpected creative forms of behaviour. To contextualise this idea we will examine two examples in which the environment and a new conceptual model for an autonomous robotic agent, in the context of the subject matter, acts as structural diagram of forces upon the artwork.

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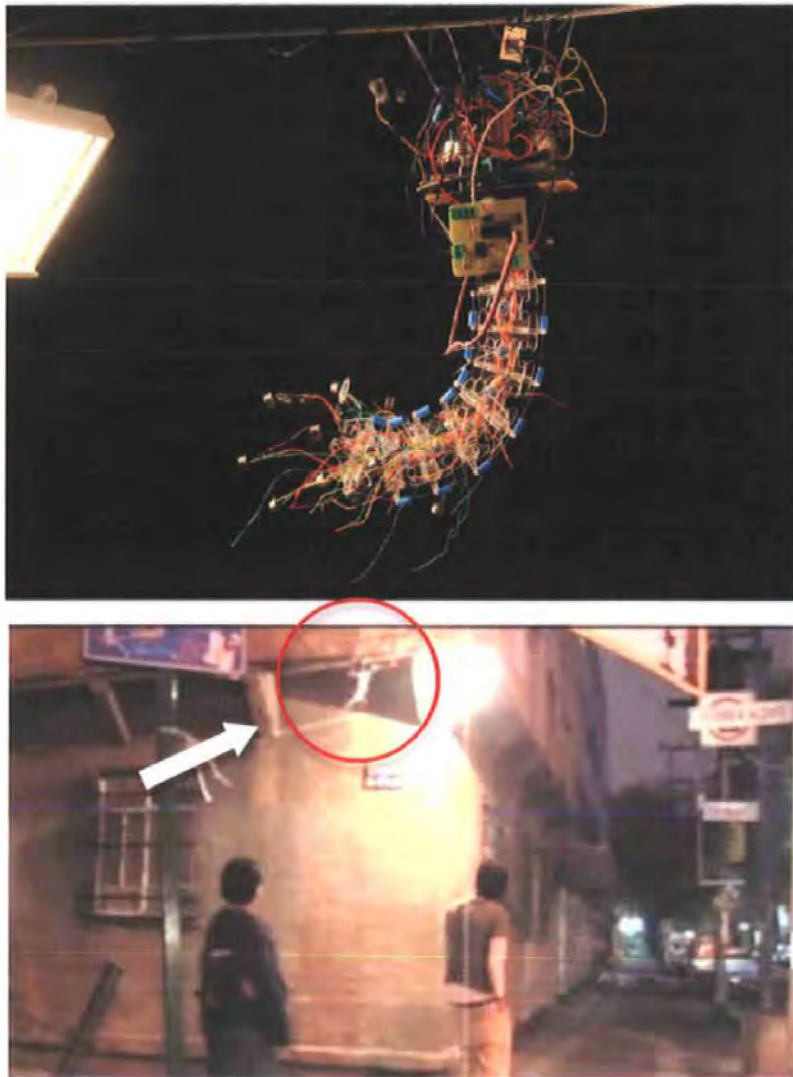
<sup>86</sup> Organized by the Museu d’Art Contemporani de Barcelona (MACBA) (April 19 – June 18, 2000), in association with Hayward Gallery, London (July 13 – September 17, 2000).

#### 4.5.2.1 The environment

*Parasitas Urbanos* (Urban Parasites), an art project of Gilberto Esparza, comprises a series of “artificial life forms”, as he calls his small robots, which are meant to inhabit the urban scenario. Part of his project is concerned with the creation of what could be called an ecology of technical organisms whose purpose is to be inserted into urban contexts and become intergrated with the landscape through their presence and sound. Esparza describes his project as such:

“Urban Parasites” proposes to create a species of robot insects built out of technological and industrial waste materials. Like all parasites, they will depend on an energy source, in this case the streetlamps of the hyper-populated city of Mexico D.F. These bugs will have motorized legs to allow them to move around and get away from approaching pedestrians. (...) These parasites can be defined as beings that subvert the urban context, but that also depend on such environment for survival. (Esparza 2009)

These ideas were materialised in the form of works whose descriptions always refer to their supposed families or classes, such as *helmintos*, *alambrópodos*, *mecatrópodo* or *autotrofos*. *Maraná*, for instance, is a parasite that belongs to a family of *helmintos* (helminths). Its body is made of acrylic parts and electronics, and it depends on light sources to create movement and emit sounds. The image below (see fig. 21) shows *Maraná* in detail and behaving on site.



**Figure 21:** *Marañ*. Source: (Esparza 2009).

*Diablito*, (see fig. 22) a species from the family he calls *mecatrópo*, inhabits the electric lines of the city, feeding itself with the energy that runs in the cables.



**Figure 22:** *Diablito*. Source: (Esparza 2009).

*Autótrofos Inorgánicos* (see fig. 23) are light powered systems that transduce light into sound. When placed in the natural environment they interact with the variations in daylight and shadows in the surrounding terrain and that of passersby.



**Figure 23:** *Autótrofos Inorgánicos*. Source: (Esparza 2009).

All three of Esparza's works discussed above have the way they are presented in the public space as a commonality. They are not meant created to inhabit the confinement of the typical white cube art gallery but rather to coexist with local people in the urban environment. The subject matter of nature, city and urban space are not approached by Esparza only on a symbolic level but as site specific, where his elaborated creatures exist as part of the social milieu. From this perspective, the artwork becomes intrinsically



associated to the environment in the manner that an affective dynamic is formed between the creatures and the observer. This dynamic is founded in a paradox. As has been commented, Esparza's works are intended to be integrated into the landscape. Perhaps it may be better to term this as a re-integration, as these small robotic beings share with Ralf Schreiber's creations a common characteristic; they resulted from a re-adaptation of technological residue (see fig. 24), the remains of technological objects that were at one time already part of the urban context.



**Figure 24:** Screens captured from the Esparza's video *Proceso* (Process). The pictures show Esparza collecting technological scrap, selecting mechanisms for the creation of a robot. Source: (Esparza 2009).

When the functions and structures of these technical objects are recombined into new functions their provisory history changes and new micro-narratives emerge. They become aliens, strange beings unfamiliar to the environment they once belonged to. That tension between old/new, familiar/novel, natural/artificial is an important factor for the aesthetic experience of these artworks. They generate curiosity from the observer through a pleasurable discomfort of the unknown, as these are objects that do not belong to the

habitual social context. Coming out of habit, a considerable criterion for the aesthetics of the information age<sup>87</sup>, they become highly improbable and informative.

#### 4.5.2.2 Conceptual model

Another factor that should be considered part of the subject matter is the model upon which the dialogue between aesthetic and technology is built. This factor will be discussed through the example of the artwork “Alexitimia: An Autonomous Robotic Agent” by Paula Gaetano Adi (see fig. 25).



Figure 25: “Alexitimia”. Source: (Adi 2005).

The name “Alexitimia” (Alexithymia in English) derives from the ancient Greek terms of “a = prefix meaning lack; lexis = word; thymos = feelings or emotions” (Adi 2008).

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<sup>87</sup> Cf. discussion on Flusser, in the section “Playing with information, from *homo faber* to *homo ludens*”

According to Adi, this term, coined by psychotherapist Peter Sifneos (Sifneos 1973), refers to “a deficit in emotional cognition” (Adi 2008). As she explains, it is

a clinical concept that describes the behavior of someone who is mostly unaware of his feelings, or does not know what they signify, and hence, is not able to talk about his emotions or his emotional preferences.

For instance, if someone who is suffering is unable to express verbally his/her feelings, they may start sweating in order to “manifest the desire to communicate” (Regine 2007).

This clinical concept was taken by Adi and embodied in a robot that sweats when a participant caresses its surface. The construction of Alexitimia’s body was a process of invention involving the programmability of an apparatus, with levels of codes and hardware, co-ordinated with the traditional problem solving of sculpture making. Through this process a mixture of soft and flexible materials such as clay, latex, plastic tubes, water, piezoelectric film sensors and microcontrollers were combined in order to give an organic appearance and behaviour to the overall structure. For Adi, the process of creation of robotic artworks, unlike other forms of art making, “get from sculpture characteristics and problems related to the form and the materiality” (Adi 2005).

The significance of “Alexitimia” is manifold. Firstly, taking the alexithymic symptom as the subject matter for the construction of a robot subverts the relationship of form and function in which robots are normally constructed<sup>88</sup>. “Alexitimia” is not a robot aimed to fulfil an objective goal or utility. Secondly, on top of the relationship between form and function comes an affective attribute; a symptom – the alexithymic identity – that is manifested artificially through the artwork’s bodyhood. As a result of this, the way interactions with “Alexitimia” occur goes beyond a purely mechanic level to a meta-level in which a conceptual layer entwines with the machine to form an artificial somatic self. It

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<sup>88</sup> One of the maxims of modernism was “form ever follows function” coined by the American architect, Louis Sullivan (Sullivan 1896).

is this layer that allows the observer to develop an affective connection with the artwork; it is between the artificially constructed body of the robot and the observer's body that a dialogue takes place, a "corporal dialogue" (*Ibid.*) in which mind and body and the natural and artificial are unified.

It is important to note that the aesthetic qualities of "Alexitimia" is neither simply a result of its interactive capacity or a result of the apparatus emulating sweating. Rather, it emerges from the combination of its structural and behaviourist qualities and the model they subscribe. In the light of the concept of apparatus (Flusser 1984) we see that the "Alexitimia" project responds to the experimentalism that is suggested as a criteria to achieve creative freedom. Adi developed her autonomous robotic agent "feeding inside its system new concepts, new models, forcing the apparatus to behave in a meaningful way"<sup>89</sup>; it is this experimentalism that marks the difference between art and purely functionality. This will now be examined more closely.

Contrasting with Adi's project is the development of SAM (see fig. 26), a "Sweating Agile Thermal Manikin", developed by the British physicist and physiologist Mark Richards. SAM is a life size mannequin provided with 125 "sweat nozzles" that gives the manikin the capacity for "accurately simulating the human body in terms of heat loss, perspiration and movement" (EMPA 2009). It is an autonomous robotic system with a sophisticated design developed to accomplish a specific goal-oriented task – "to allow the heat losses to be more accurately measured" (*Ibid.*). It behaves and interacts with the user in order to perform precise and purposeful actions. SAM is absent of any aesthetic value in this context, proving that behaviour and interaction is not enough.

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<sup>89</sup> Cf. section "Being experimental. Hacking the apparatus programme" in Part I of the thesis.



**Figure 26:** SAM and its creator. Source: (EMPA 2009).

“Alexitimia”, in contrast, does not subscribe an agenda driven by the search of new methods of simulating human intelligence and behaviour. Instead, it builds an aesthetic discourse upon the dialogue with those premises within artificial intelligence that considers “human beings and their computational reproductions [as if they were] only an information processing system” (Adi 2008, p. 7). This aesthetic discourse emerges from the intersection between the robot’s “alexithimic personality” (the model, subject matter) and its behaviour (structure and functions). As Adi states:

The elimination (or concealment) of the bounds between the personality and the behavior of this alexithimic robot is considered, in this work, as an aesthetic form that outlines the rupture of a dualistic hard/soft structure (or mind/body configuration).

The aesthetic discourse is built upon language and emotion, becoming apparent through a process that involves transubstantiation through transduction. Language and emotion here shall be interpreted in light of Humberto Maturana’s approach. Maturana stated that languaging is what defines “our manner of existence as human beings” (Maturana 1997).

Language is a manner of living together in a flow of consensual coordination of coordinations of consensual behaviors, and it is as such a domain of coordinations of coordinations of doings.

Maturana also said that before language, innate emotion was the parameter that coordinated ours ancestor’s behaviours.

Previous to the recursive coordinations of consensual behaviors of language, our ancestors as all non-linguaging animals do, coordinated their behaviors through their consensual and innate emotioning. That which we connote as we claim that we distinguish an emotion in other human beings, in non-linguaging animals, or in ourselves, is the domain of relational behaviors in which we think that we are, or that that other being is. (*Ibid.*)

Maturana terms this consensual interlace of language and emotions “conversation” (*Ibid.*). The reason for drawing upon Maturana’s observation in this research is that the work of art does not exist outside of the scope of such a conversation between the observer and the artwork. It is the capacity to address meaning in a given context that allows the observer to experience the transubstantiation of information into an aesthetic field.

The term transubstantiation comes from a lecture given by Marcel Duchamp at the Convention of the American Federation of Arts (Duchamp 1957). Duchamp stated that the artwork is a catalyst of an “aesthetic osmosis”, a process that is activated between the artist and the spectator through which an “art coefficient” is transferred. As he explained:

(...) “art coefficient” is like an arithmetical relation between the unexpressed but intended and the unintentionally expressed. (...) “art coefficient” is a personal expression of art à l’état brut, that is, still in a raw state, which must be ‘refined’ as pure sugar from molasses by the spectator (...). The creative act takes another aspect when the spectator experiences the phenomenon of transmutation: through the change from inert matter into a work of art, an actual transub[s]tantiation has taken place, and the role of the spectator is to determine the weight of the work on the aesthetic scale. (Duchamp 1957)

The creative act was conceived by Duchamp as: “the difference between the intention and its realization” (Judovitz 1998, p. 111). The aesthetic dimension occurs in the interstitial zone between the artist’s intention and the observer’s response. Although this is a valid point, it is possible to question whether the simple assignment of an “artistic” function to an artificial system furnishes it with an aesthetic quality. For example, would the simple shift of “SAM from its native industrial domain to the exhibition space – similar to Duchamp’s act with the urinal he signed R. Mutt – still unfold an aesthetic value?

“Alexitimia” appears to suggest that it does not proceed from a simple transubstantiation of “inert matter” into a work of art. As a behaviourist artwork the

transubstantiation depends on transductions<sup>90</sup> occurring in the artwork's structure. During this thesis such behaviourist artwork has been termed a "hyperorganism". As such, it is able to perform transformations of energy in time, a feature that identifies its specific behaviour and bodyhood. The aesthetic value attributed to "Alexitimia" comes from the intrinsic play of forces generated by its behaviour (its capacity to emulate sweating), its personality (alexithimic concept) and the observer's intention to address meaning. It is an interlace of structure, subject matter and a dialogical conversation that manifests in an integrative field. "SAM" does not depend on such an arrangement to work successfully. Its primary relation to its user is of cause and effect, there is no need of any sort of transubstantiation to take place. In turn, "Alexitimia" only fulfils its "aesthetic function" if its behaviour and personality persuades the observer to engage in a conversation.

### **4.5.3 Equilibrium**

The final of the five topics being examined in this section is equilibrium. This sub-section will examine how equilibrium acts as a vector of force that informs what we have conceptualised as the integrative field. In Arnheim's Gestalt approach, equilibrium is conceived as being the final state of "accomplished order and maximum relative entropy" (Arnheim 1974b). It means that the artwork is in a state of equilibrium, has achieved its structural balance and is found at standstill, presenting the maximum informative aspect. Taking on board this perspective against the framework of the behaviourist art it is necessary to reconsider that the artwork is not at standstill but in a metastable state; the

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<sup>90</sup> Transduction in this context means the transformation that occurs between two different forms of energy. The transductive process is crucial for the hyperorganism's homeostasis and for its capacity to behave according to its conceptual model. It is a concept developed by Simondon that refers to the process of individuation in technical objects. It was investigated further by Adriam Mackenzie in his book "Transductions" (Mackenzie 2002).

interactions between the structural theme and equilibrium are not only a privilege of a closed process of invention (unidirectional model) but it is also opened to outside intervention from the observer. Under such a condition the artwork's metastable state is disrupted by the observer's presence and the balance of the system is altered and a provisional equilibrium is achieved. In this "maximum relative entropy" a higher informative state is accomplished by the presence of the observer as a result of a conversation that involves meaning and information.

As an illustration of these ideas a work developed by the author of this thesis will be presented. This artwork received the homonymous title "Equilibrium". "Equilibrium" is part of a series of projects that were comprised of drawings, videos and robotic pieces organised under the conceptual umbrella named "Leaves System". "Leaves Systems" explores poetically the hybridisation of natural and artificial systems and was motivated by the search for new models of biological agency that could be drawn into the apparatus system. The goal was to allow for new effective/affective modes of conversation with the observer of the work of art. The core of "Leaves Systems" lies in the use of plants (hence "Leaves") as natural organisms working symbiotically with an artificial counterpart. These projects and their conceptual background will be reported in detail within the section of the thesis entitled "Practice Work". However, for the present discussion only the "Equilibrium" related work will be addressed.

"Equilibrium" is a hyperorganism in which a plant and an artificial system share a mutual relationship. This hybrid system is composed of two small motors, solar cells, microchips, light sensors and a plant. The whole system is arranged in a balancing form that is able to spin around its axis in a manner evoking a compass. The artificial system occupies one side of the balance and is set to perform photovore (light seeking) behaviour by controlling two propellers that force the whole system to rotate either clockwise or



counter-clockwise<sup>91</sup>. A small plant is located on the other side of the balance so that when the balance rotates on its axis the plant is posited towards the light. In turn, along with the plant two solar cells absorb light and provide energy to the artificial system.

“Equilibrium” is a hyperorganism with autonomous behaviour. It belongs to a class of artificial hybrids emerging from contemporary art practices that are concerned with the mutual relationship between natural and human-made organisms. The motivation to develop “Equilibrium” began with a questioning of whether a natural living being and a machine could be integrated in a form of symbiotic system, so that the structure of the system could be beneficial to both the natural and artificial organisms. Plants, as a subject and symbiotic element, have a very important role in this piece. As an organism of the natural domain, it must be considered as a subsystem, bringing into the whole artwork its own network of meaning and beliefs<sup>92</sup>. It is not just a plant, but a plant assembled with artificial parts to behave in unison as a hyperorganism.

“Equilibrium” was created to inhabit the natural environment under the sun, as well as to share with observers an exhibition space supported by artificial lights<sup>93</sup>. Under such a condition, observers become linked within a subtle chain that interconnects plant, human and machine. When interposing themselves between the system and the artificial lights of the environment, he/she leads the creature to search for a new source of energy. In

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<sup>91</sup> This system was inspired on the ideas of Valentino Braitenberg, an Italian-Austrian neuroscientist and cyberneticist, well known by the book *Vehicles: Experiments in Synthetic Psychology*. In this book Braitenberg describes a series of conceptual experiments in which vehicles (known as Braitenberg Vehicles) comprising of simple internal structure present unpredictable and complex behaviour. The book’s main argument is that the behaviour of artificial mechanisms, whose operation principle is not known, might be interpreted as aggression, love, foresight and even optimism. The basis of “Equilibrium’s” mechanism is an analogue circuit that falls into the category known as BEAM robotics, an acronym for Biology, Electronics, Aesthetics and Mechanics, coined by the robotic expert Mark Tilden (Tilden 2000; Hrynkiw and Tilden 2002).

<sup>92</sup> This refers to the understanding of plants according to various epistemological categories: cultural, social, religious or scientific. Each one of these categories addresses the meaning of plants according to their own system of validation. This issue will be addressed further in the “Practical work” section.

<sup>93</sup> “Equilibrium was exhibited at the Art Centre Gallery, Plymouth, United Kingdom, in the event “Artists from Brazil” in 2008.

intervening in this manner, accidentally or with intent, the observer is made aware of the systems behaviour and needs. The observer engages in a meaningful conversation with the hyperorganism, until, curiously, they realise that the creature's "well-being" depends on their non-interaction.

"Equilibrium" emerges from this multileveled conversation between the observer and the hyperorganism. It poses new questions on the issue of interaction, as the relationship with the observer is not strictly based on rules of cause and effect. More than a purely interactive response to human behaviour these organisms ask for dialogues, requiring a sort of investigation into their nature as individuals (technical and natural) in order to unfold the network of meaning to which they belong. If nature is a concept, never achieved objectively, but only subjectively, and if art is one of the most powerful tools to modulate subjectivity and ultimately our consciousness, the hybrid of plants and artificial systems may bring new insights about the world we live in and its ongoing metamorphosis. And if art may be thought of as a sort of game, we must start considering also new types of players. New species made of natural and technological parts.

"Equilibrium" maintains a metastable state which keeps it alive as a hyperorganism. When such a state is disturbed by the shadow of another being it regulates itself into an alternative state of equilibrium. This is the moment in which "Equilibrium" achieves its most meaningful state, when meaning and information are entangled in the observer's mind (see fig. 27).

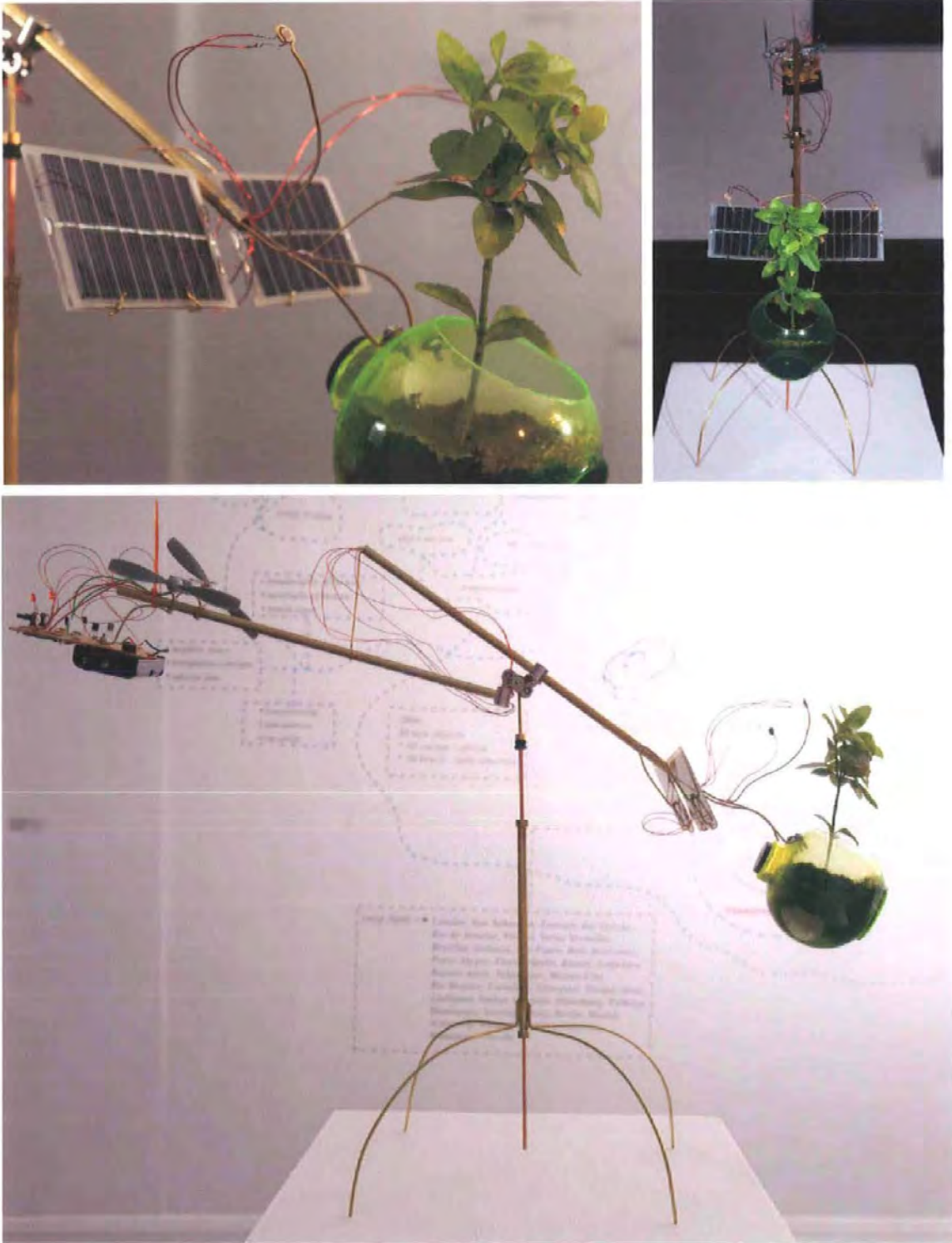


Figure 27: "Equilibrium" © 2008, Guto Nóbrega.

#### 4.6 Towards an organic theory of art

In the field of technologically assisted art, the idea of artworks as living organisms is not new. Such concepts can be seen in the work of William Latham “genetically alive forms” (Rush 1999), Christa Sommerer and Laurent Mignonneau’s (1999) idea of “process oriented artworks” as “living systems” or in Peter Weibel, to whom the digital image approximates a living organism due to three characteristic elements: virtuality, variability and viability (Weibel 1997, p. 178). In Weibel’s words:

If we define a living organism as a system characterized by its propensity to react relatively independently to any number of inputs, then it follows that a dynamic virtual system of multi-sensorial variables will approximate a living organism and its behavioural patterns. (*Ibid.*)

These views have their roots in the idea that life, as a result of material organisation, can be simulated by artificial means, primarily through computation. This idea, supported by concepts from evolutionary theory, molecular biology and theories of complex systems can be traced to the often cited work of Christopher Langton, whom is acknowledged as one of the instigators of the field of artificial life (AL) (Langton 1989). According to Langton’s perspective, “living organisms are nothing more than complex biochemical machines” (*Ibid.*) whose organisation emerges from dynamic, non-linear interactions of a “large population of relatively simple machines” (Johnston 2008). For Langton, life does not need to acknowledge any sort of “vitalistic”<sup>94</sup> principle, therefore biological phenomena can be synthesised and extended through the use of “computers and other ‘artificial’ media” (Langton 2000). By definition,

[a]rtificial Life is the study of man-made systems that exhibit behaviors characteristic of natural living systems. It complements the traditional biological sciences concerned with the analysis of living organisms by attempting to synthesize life-like behaviors within computers and other artificial media. By extending the empirical foundation upon which biology is based beyond the carbon-chain life that has evolved on Earth, Artificial Life can contribute to theoretical biology by locating life-as-we-know-it within the larger picture of life-as-it-could-be. (...) Only when we are able to view life-as-we-know-it in the larger context of life-as-it-could-be will we really understand the nature of the beast. Artificial

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<sup>94</sup> Vitalistic in the sense of Vitalism, the doctrine that saw properties of organic life as a result of a distinctive “spirit” or vital fluid that infuses life to them (Bechtel and Richardson 1998).

Life (...) is a relatively new field employing a synthetic approach to the study of life-as-it-could-be. It views life as a property of the organization of matter, rather than a property of the matter which is so organised. (Langton 1989, pp. 1-2)

The research discussed in this thesis, however, focuses on a different aspect of biological phenomena. It is suggested here that if a piece research really wants to tackle creatively “life-as-it-could-be”, firstly there must be consideration for life-as-it-is-still-unknown. AL is grounded on the process of synthesis in a similar manner to how it is applied in synthetic chemistry – the capacity to “put together new chemical compounds not found in nature” (Langton 2000). More precisely, AL aims to move towards “synthetic biology” (*Ibid.*) to fulfil “the attempt to recreate biological phenomena in alternative media” (*Ibid.*). In fact, the AL discipline holds in its title a paradox, as its main concern is not life but emergent behaviour. “What matters is what they [synthetic living things] do, not whether they are alive”.

The investigation of behaviour in post-modern aesthetics appears to have been a necessary transition in order to lead to the concepts of structural dynamics that can be witnessed now in contemporary interactive art. But in arts, behaviour in itself is not enough, as well as homeostasis is not enough (Arnheim 1974b).

For a more adequate view of human nature it is necessary to take into account the goals of life, the striving toward growth and stimulation, the lures of curiosity and adventure, the joy of exercising body and mind, and the desire for accomplishment and knowledge. (*Ibid.*)

An account of these issues is not founded upon the synthetic rearrangement of molecular structures and emergent behaviour as found in AL. The idea of the aesthetic organism that is proposed in this thesis is not intended to mimic organic behaviour, but rather to be in essence a living coherent structure of its own, taken from a perspective that understands that art is, in reflection, a property of life. In the argument developed here, information technology offers the artist the conditions to explore life, not in its appearance, but as a model for creative expression. As Johann Wolfgang von Goethe asserted, the artist

should aim for "... not only something light and superficially effective, but, as the rival of nature, something spiritually organic ... to a content and a form by which it appears both natural and beyond nature" (Goethe 1980 cited in Whitelaw 2001).

The notion of "Life-as-it-could-be" could be a source of inspiration for arts, but in following this path it is impossible to avoid the often addressed question: what is life? How might the organic inspire artists? Also, how might art and technology nourish new metaphors in resonance to what is still unknown about life? These questions could lead to straight answers, but the subject calls for a more subtle analysis. The ideas of Jack Burnham may provide a useful insight in this area.

In *Beyond Modern Sculpture* (Burnham 1968a) Burnham dedicated an entire chapter to the influence that the philosophy of "vitalism"<sup>95</sup> had on modern sculpture. This was prominently seen in the work of Rodin, to whom "When a good sculptor models a torso, he not only represents the muscles, but the life (...) which animates them – more than life, the force that fashioned them" (Rodin cited in Burnham 1968a, p. 55) or in the work of Henri Moore, whom stated that "a work must first have a vitality of its own. I do not mean a reflection of the vitality of life, of movement, physical action, frisking, dancing figures and so on, but that work can have in it a pent-up energy, an intense life of its own,

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<sup>95</sup> Vitalist theory held that living organism are in essence different from non-living entities due the existence of a distinctive "spirit" or vital fluid that infuses life to them (Bechtel and Richardson 1998). Although the roots of Vitalism can be traced back to Aristotle and the concept of *entelecheia* (the vital force that guides the organism towards self-fulfilment (Sachs 2009), the concept of *vitalism* was developed in opposition to the mechanist account of biological system formulated by René Descartes and his successors. The concept of *entelecheia* appears notably in the work of the eminent embryologist Hans Driesch (1867–1941), and also in the work of the French philosopher Henri Bergson (1874–1948). Bergson developed the concept of *élan vital* in his book "Creative Evolution" (Bergson [1911] 1964) as essentially a common impulse that drives and explains the creation of all living species. On the other hand, mechanistic theories of organic matter postulated that life can be fully accounted in terms of "analyzable physical functions and combinations of matter" (Burnham 1968a). The origins of such a concept goes back to René Descartes and his assertion that "animals, and the human body, are 'automata', mechanical devices differing from artificial devices only in their degree of complexity" (Bechtel and Richardson 1998). *Vitalism* grew up in reaction against a mechanical conception of life (Needham 1935), however, the consideration of a vital sprit or mystical fluid as explanation of life stands as an obstacle averse to the very scientific dogma, the spirit of enquiry.

independently of the object it may represent” (Rodin cited in Burnham 1968a, p. 55). Supported by the work of Henry Bergson and historians such as Herbert Read and Henri Focillon, Burnham attended to the poetics of “vitalism” as a philosophical and scientific idea in modern sculpture. Curiously, Burnham’s thesis, and the reason to bring the aesthetic of “vitalism” into light, was to show at that time that

formalist and vitalist sculpture represent two preparatory tendencies which symbolically anticipate the re-creation of life through nonbiological means, that is, through technology. In this instance classical machine parts such as gears, pins, cams, and bearings plates (reduced to their basic geometric equivalents) are equated in the subconscious of industrial society with the life force itself. (...) In part, formal sculpture became the reconstruction of life through the simulation of machine forms (...). (Burnham 1968a, p. 9)

Also, Burnham continues,

Today the intellectual sights of vitalism are aimed at another target: the realm of computer technology, which encompasses artificial intelligence and computer creativity. It remains to be seen if this new “offense to the human spirit” will be crushed – or will become another triumph for the mechanists. Slowly the criterion of vitalistic life has changed from physiological to neural perspectives. (Burnham 1968a, p. 65)

At the end of his book he concluded:

Taking the path outlined up to now, it would be logical to speculate on the quasi-biological nature of future art. Such a possibility depends upon a radical realignment of the human psyche with the increasing sophistication and autonomy of our technical systems. *It also implies a gradual phasing out, or programmed obsolescence, of all natural organic life, substituting far more efficient types of life forms for our “inferior” and imperfect ones.* Would this be art as we have come to know it, or would it be the culmination of what futurologists term Faustian urge, the grand illusion of a society convinced of its own scientific omnipotence? (Burnham 1968a, p. 376 italics added)

What appears to be a paradox in Burnham’s argument is how the doctrine of “vitalism” combined with an account for life understood as what cannot be grasped in mechanistic terms indicates the anticipation (even symbolically) of the re-creation of life through nonbiological means. When the vital impulse (driven by the artist) and the inert matter come together as a sculpture, it is the power of life that is amplified via the metaphors of art. When life is “re-created” through inorganic technological media by a process of synthesis, there is no requirement for metaphor or any process of

“substantiation” (Duchamp 1957) to take place. A “vitalist” aesthetic would thus be reduced to “mechanist” aesthetic.

Earlier in the thesis the idea of an aesthetic organism was introduced, a concept that emerges from the embryonic confluence of the observer, the artist and the artwork, here understood as an hyperorganism<sup>96</sup>. This model unites two fundamental concepts: field and coherence. It takes into account the role of information and entropy in forms of communication, such as arts, not from the perspective of inorganic matter but from the point of view of living organic systems. The present study has searched for a theoretical model that may support the analysis of such an aesthetic structure. Such a model should take into account the importance of coherence in the understanding of living systems. Moreover, the theoretical biological model should be scientifically robust without being reductionist. A model that could be considered integrative has been searched for, in the sense that it pays attention to the relevance of the various structural parts without losing sight of the dynamics of the whole. This suggests what might be necessary is a balance between intuition and rationality, introspection and projection. In essence, this model should take into account the view of living organisms and arts as a field phenomenon. Such a conceptual and practical model is available at a point of convergence between physics and biology, specifically in the field of integrative biophysics and the research of biophotonics. The next stage of the study will survey the main theoretical and practical issues relative to the field of biophotonics. The following section will conclude with an analysis of the aesthetic organism in light of its main theoretical issues; the coherence and integrative field of living organic matter.

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<sup>96</sup> Cf. section “The behaviourist artwork as a hyperorganism”.



## **PART III: SCIENCE**

### **Biophotonics and the integrative field approach**

#### **5 The biophotonic model**

The conceptual link between arts and biophotons can be traced to Roy Ascott's paper "Biophotonic Flux: bridging virtual and vegetal realities" (Ascott 2003a). In view of the multifaceted artistic possibilities that are nurtured by contemporary scientific and technological discoveries, Ascott speculated of an aesthetic bridge between the quantum communication system of cells and molecules and the macro information network we have built across the earth.

Telematics and Mixed Reality technology, now central to artistic practice, can become the instruments of ontological and epistemological inquiry. In this respect, the new frontier field of biophotonic research may prove to be crucial in our understanding of the human organism's systems of communication, and provide a conceptual link to the telematic networks we are weaving over the face of the earth. (*Ibid.*)

Ascott's attention to biophotonics was driven by Jeremy Narby's observation of correlation between his research on the origins of shamanic visions and the contemporary biophysical investigation of quantum coherence in living organisms. Both lines of enquiry held in common the speculative argument of the DNA as a source of light. To be more precise, in biophotonics the deoxyribonucleic acid is the main candidate as the primary source of a bionetwork of electromagnetic radiation, which supposedly serves as main communication channel of the organism. The biophysicist Fritz-Albert Popp christened the main component of this dynamic communication field, "biophoton".

Roy Ascott's conceptual approach to this field traced notable parallels between telematic communication and the biophoton phenomenon.

The importance of biophotonic research for the artist is yet to be established but I am disposed to believe that the parallelism between the body's internal communication network of light and the external environment of telematic communication offers considerable room for conceptual creativity. The orchestration of light in a pervasive harmony is equally the potential for wholeness of mixed reality technologies, whereby the artist and scientist might join in the extension of the human biofields into new domains of experience. It is here, in the illumination of biologically effective fields, that art will become more visibly proximate to healing. It is clear to me that research in biophysics, not least in the area of biophotonics, and that of electro magnetic fields, will play a significant part in the evolution of moist media, the substrate of 21st century art, embracing crossovers between telematics, neuroscience, biology, quantum physics, and nano-engineering in the work of artists, designers, performers and architects. (*Ibid.*)

The present study has developed two specific approaches regarding biophotonic research. The first approach investigates biophotons as a functional model for the creation of aesthetic organisms. Material, methods, theories and biological impact was analysed in detail and reported on in the following sections of the thesis. Despite the fact that the theory of biophotonics has been available in an extensive list of journals and books, the majority of the material available does not approach biophotonic research from an artistic point of view, nor draws conclusions of aesthetic nature. The aim of this section, from a practical point of view, is to map the main theoretical questions of the subject, offering an extensive bibliography and review within the field allowing for future investigation.

The second approach addresses biophotonic research as a conceptual model for the analysis of aesthetic organisms. The hypothesis of this thesis is that the aesthetic dimension of the artist, artwork and observer triad, as discussed previously in this thesis, can only be fully unfolded if the interactional forces of that triad in terms of an integrative field phenomenon, which has been termed an iField, are taken into consideration. Biophotonic research offers a picture of living organisms in terms of an integrative field model in which parts and whole resonate in unison of communication. The mechanism behind this process is coherence.

If the global information network reflects in some way our internal organic apparatus, it confirms that technology could be considered a type of mirror of ourselves

(Rokeby 1995, p. 133). Therefore, it is suggested by this thesis that coherence is the image in the mirror that reflects the resonant couplings within and between living systems and the resonant couplings within and between aesthetic organisms.

The following section will survey some of the main aspects of biophoton research, focusing on its bio-informational character and the coupling of organic systems via a coherent field of radiation. This survey is based on the review of the main literature in the field of research; personal experience gathered by the author upon attending the Summer School of 2006 at the International Institute Of Biophysics (IIB); a short-term scientific exchange at the same institute in which the author followed the Brazilian electric engineer Cristiano de Mello Gallep's experimental procedure with spontaneous light emission of wheat seedlings sprouts; visualisation of delayed luminescence of plants with the aid of CCD<sup>97</sup> image system at the IIB; visiting the Department of Optical Sciences and Medicine College of Optical Sciences, University of Arizona to exchange with Gary E. Schwartz and his research group, which runs experiments in biophotons and healers; and finally interviews with the writer Marco Bischof and the researcher Melinda H. Connor.

It is important to reiterate that the present discussion regarding biophoton phenomenon proceeds from an artistic point of view and insight taken from first-person experience. This research conjoins in its methodology a practical/discursive analysis of an integrative field model of living organisms, viewed from two particular perspectives: art and science. The goal is not to apply a scientific model to art, but to show points of intersection between the disciplines through creative approaches towards life. As a conclusion, it will be demonstrated how the integrative view of living organisms as bio-information systems might work as a conceptual model for the creation and analysis of aesthetic organisms.

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<sup>97</sup> Abreviation for charge-coupled devices.

## 5.1 Understanding photons: basic principle

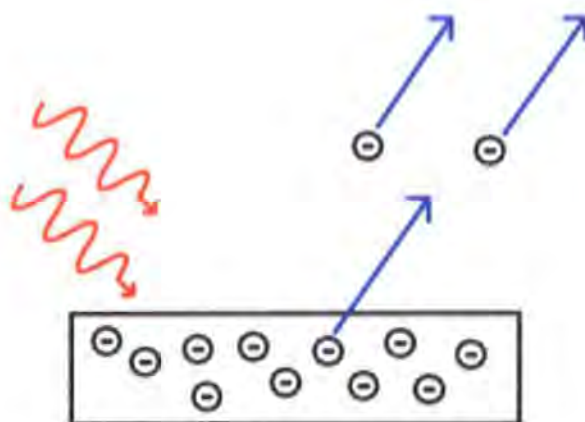
The understanding of the biophoton phenomenon requires one to grasp the meaning of photons and the alternative perspective of physical reality that is introduced by quantum mechanics. The word photon derives from the Greek word "phōs", meaning light. In quantum physics it is the term used to designate a quantum of electromagnetic radiation. It remounts back to Max Planck's hypothesis (Planck 1901) that "the radiant energy could exist only in discrete quanta" (Nave 2006). Planck's concept replaced the previously dominant perspective of light phenomenon that was based on Newtonian laws of nature, formulated on the book "The Mathematical Principles of Natural Philosophy" (Newton et al. [1687] 1729)<sup>98</sup>. Newton had postulated that the brightness of a body increases *uninterruptedly* and proportionally to the frequency of its electromagnetic radiation.

According to what became known as the "Planck hypothesis", "all electromagnetic radiation is quantized and occurs in finite 'bundles' of energy which we call photons" (Nave 2006). This introduced the "quantum" concept to radiation. In 1905, an article written by Albert Einstein titled "On a Heuristic Viewpoint Concerning the Production and Transformation of Light", which won him the Nobel Prize in Physics in 1921, gave a mathematical explanation for the phenomenon known as "photoelectric effect"<sup>99</sup> (see fig. 28) in which he substantiates the notion of light as streams of particles, also establishing the wave-particle duality, a paradox by which photons exhibit both wave-like and particle-like properties.

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<sup>98</sup> Original in Latin: *Philosophiæ Naturalis Principia Mathematica*.

<sup>99</sup> The photoelectric effect was observed in a experiment that showed that the amount of energy produced by certain materials when absorbing light does not depend on the intensity of the radiation but its frequency, opposing the, at the time accepted, wave theory of light (Nave 2006).



**Figure 28:** “The photoelectric effect. Incoming photons on the left strike a metal plate (bottom), and eject electrons, depicted as flying off to the right.” Source: Wikipedia.

Photons are a mind-boggling phenomena, which even the trained physicist Albert-Fritz Popp finds difficult to define it in a simple sentence, although he provides a useful core definition for the discussion in this thesis.

The most reasonable (and at the same time easily understandable) imagination of a photon may be obtained by looking at it as a process rather than as a particle. (Popp 1994)

## 5.2 What are biophotons?

It is popularised among physicists that electromagnetic radiation (the heat transfer) of a body, resulting from the movements of atoms and molecules, depends primarily on its temperature - as described by Planck’s law (Planck 1901). It is also known that living organisms do not reach the temperature required to emit visible light, such as an incandescent light bulb does, that could be seen by the naked eye. However, it appears to be the case that, all living biological systems, including human beings, continuously and spontaneously emit light at a very low intensity, although this is so weak that it cannot be

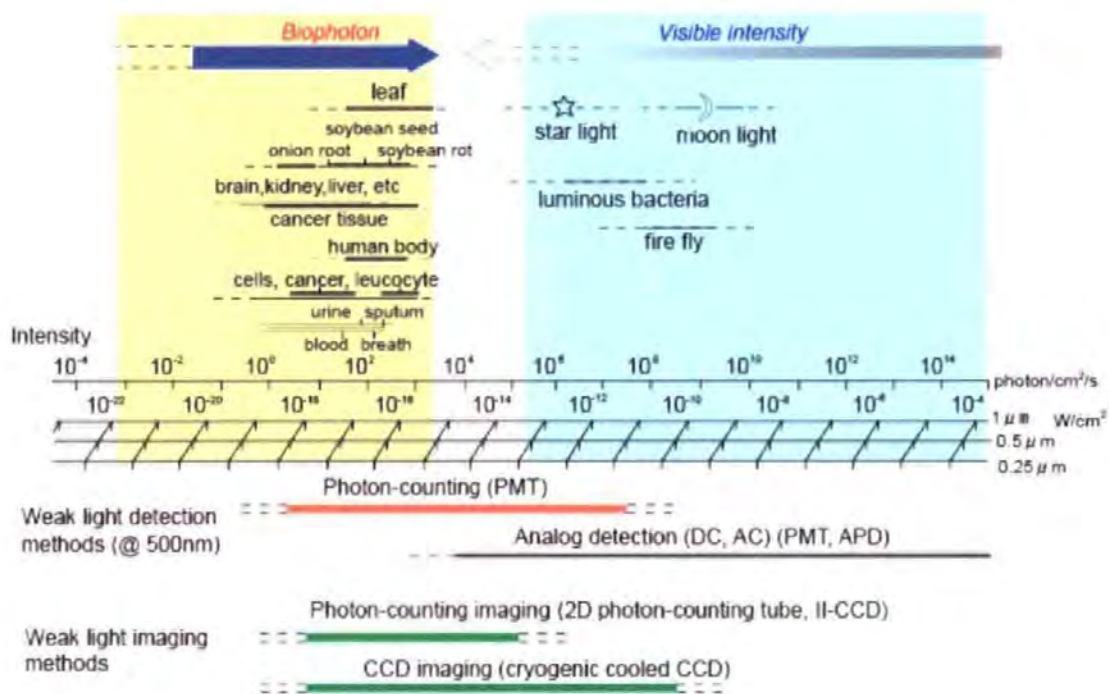
perceived without the use of appropriated instrumentation. This cellular glow, also known as “biophoton emission” (Popp 1988), should not be confused with bioluminescence (also known as “cold light”), which is a natural phenomenon observable in some vertebrates and invertebrates, as well as microorganisms and terrestrial animals. In these latter cases, light appears as a result of luciferin-luciferase chemical reactions and can be easily seen by the human eye (Popp 1994) (see fig. 29).



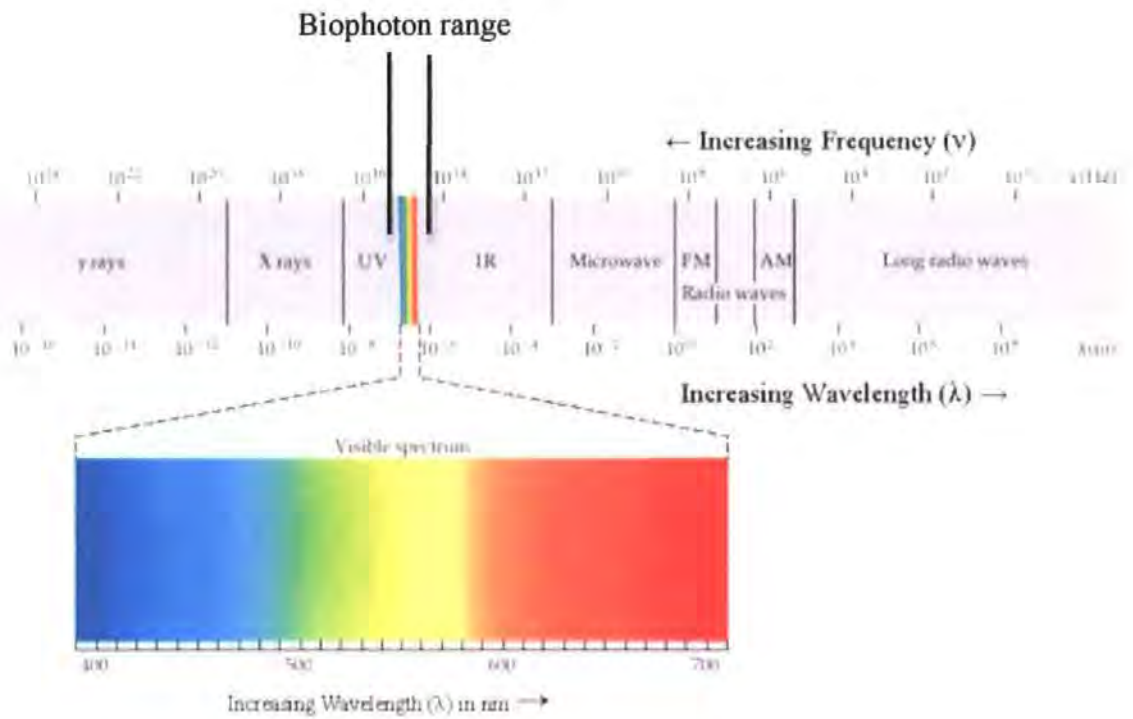
**Figure 29:** Clockwise from left top: flying and glowing *Photinus pyralis*; Female of *Lampyris noctiluca*; a wave of billions of *Lingulodinium polyedrum* dinoflagellates, a phenomenon also known as “red tide”. Source: Wikipedia.

Biophotons must be set apart from general bioluminescence. They are ultra weak light ranging from  $10^{-16}$  to  $10^{-18}$  W/cm<sup>2</sup> (Cifra 2006). Biophotons manifest within the spectral frequency ranging between 200-800 nanometers, which means they begin within the infrared portion of the light spectrum extending through the whole visible range into the

ultra violet section (Popp 1979) (see figs. 30, 31). Contrary to bioluminescence activity, “biophoton emission is permanent” (Popp 1994).



**Figure 30:** Intensity range of biophoton emission phenomena against human eye sensitiveness and instrumentation. Source (Inaba 2000; Kobayashi 2009).



**Figure 31:** Biophoton spectral frequency range.

One of the leading researchers of biophotonics is Masaki Kobayashi, physicist at the Tohoku Institute of Technology in Sendai, and he defined the biophoton as

a spontaneous photon emission, without any external photo-excitation, through chemical excitation of the internal biochemical processes underlying cellular metabolism. Biophoton emission, originates in the chemical excitation of molecules undergoing oxidative metabolism. It is distinct from thermal radiation arising from body temperature. (...) Biophoton phenomenon has been surveyed from cellular or subcellular levels up to individual organism level, following the development of the highly sensitive photon detection techniques. (Kobayashi 2009).

Despite the low intensity of such a light emission, biophotons present a very peculiar attribute. There is a general consensus among several scientific groups (Popp 1981; Bajpai 1998; Inaba 2000; Kobayashi and Inaba 2000; Gallego et al. 2005; Creath and Schwartz 2005a; Belousov and Voeikov 2006) that this ultra-weak radiation field plays an important role in the regulatory system of living organisms by which it is emitted. The work of Fritz-Albert Popp claims to provide evidence that biophoton emission must be associated with biological and physiological functions, showing that (1) biophotons are



highly sensitive to environmental changes, (2) they behave in resonance with physiological processes in which it acts as its regulator, and (3) they are of non-thermal character and have a high degree of coherence (Popp et al. 1984; Mei 1994; Devaraj et al. 1997). Correlations between life activities and biophotonic emission strongly suggest the possibility that this phenomenon might be the basis of a biocommunication network of light, highly coherent, which situates biophotonic phenomena as a potential new way to understand life (Bischof 2005), in which coherence takes an vital role. According to Marco Bischof, (author of *Biophotonen - Das Licht, das unsere Zellen steuert*<sup>100</sup> - an extensive publication on the subject of biophotons) “this radiation is very, very weak, but it is not like an ordinary light, because it is coherent. Like laser light. (...) But the interesting thing is that this light is much more coherent than any laser that is possible to make” (Bischof 2006b).

The research in biophoton emission has set itself some fundamental questions to be investigated: “The origin of the biophoton field, the rather high stability of its emission intensity, the spectral distribution, its degree of coherence, and, of course, its biological significance” (Popp 1994).

### **5.3 Biophoton, historical background**

Although the research of the biological implication of photon emission from living organisms has been studied for more than eighty years, this research topic reflects a subject inadequately studied within mainstream biology (Wijk 2001, p. 183). Throughout the trajectory of this area of research three main phases have demarcated its lines of enquiry.

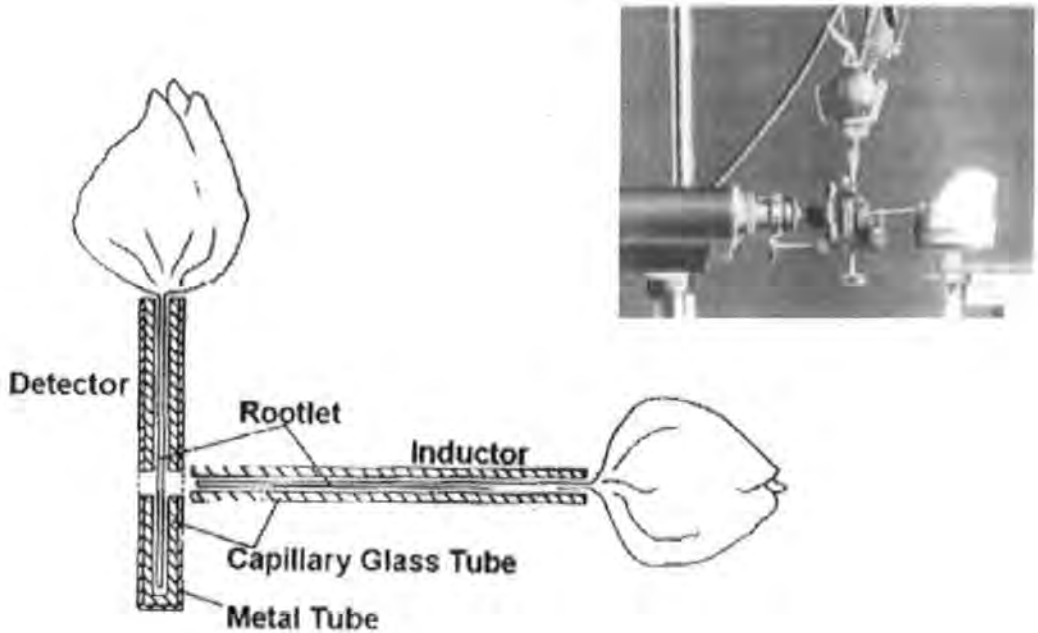
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<sup>100</sup> Summary of contents in English at <http://www.marcobischof.com> and extensive introduction to the subject of biophotons and integrative biophysics on the book “Integrative Biophysics. Biophotonics” (Bischof 2003)

The first stage was characterised by Gurwitsch's approach, in which biological organisms were used as detectors for mitogenetic radiation. The second stage was characterised by the use of sensitive photomultiplier tubes, which worked as detectors of radiation from organisms and cells. This phase placed more attention on the speculated "chemical and enzymatic origin of radiation" and less consideration to the bio-informational character of the photon emissions (*Ibid.*, p. 184). The third phase, the phase that this research gives careful consideration to, focuses on the informational aspects of photon emission from living organisms (*Ibid.*). This third phase, strongly influenced by Gurwitsch's approach, aims to see beyond the reactions and biochemical causalities that have been given as explanation for this phenomenon, considering instead the relevance of the informational aspect of the photon emissions that are involved. This newer perspective in this subject area suggests "the existence of a coherent electromagnetic field within cell populations and has led to the introduction of the term bio-photons [or biophotons]. Bio-photons are characterised by their quantum character and are supposed to escape from a coherent field" (*Ibid.*).

In the 1920's Alexander Gurwitsch (1874-1954), a Russian biologist, introduced the concept of "morphogenetic field" to biology suggesting the existence of a coherent activity of embryonic cells regulated by optical interference (Belousov and Popp 1995). Gurwitsch was led to this hypothesis after his observation of an ultra-weak photon emission from living systems. Gurwitsch's research was motivated by the search for an answer to a fundamental question of the life sciences: "how tissues transform and transfer information about the size and shape of different organs" (Popp 2003a). His experiment was performed

using approximately 130 pairs of onion roots<sup>101</sup>, (Gurwitsch 1923a cited in Wijk 2001), set up as “detector” and “inductor” according to the figure below (see fig.32).



**Figure 32:** Set up of Gurwitsch’s experiment with onion roots. (Popp 2003a).

This configuration allowed Gurwitsch to observe that cells dividing in the tip of inducer root influenced the cell division in the detector root (the detector), and, more significantly, that the mitotic activity on the “detector” root stopped being stimulated by the “inducer” if a sheet of window glass was placed between them. When the window glass was removed and substituted by quartz glass (which allows the passage of UV light at 260nm) the mitotic division rate returned to increase considerably (*Ibid.*). As this phenomenon could not be explained neither chemically nor mechanically<sup>102</sup>, Gurwitsch’s

<sup>101</sup> Onion roots were chosen due to their radial symmetrical arrangement, which suited the architecture of the experiment.

<sup>102</sup> As a starting point, the effect of chemical substance was considered as the possible cause of the increasing mitotic rate, however, the spatiotemporal character of the relation between “cell division frequency and cell surface area” led to a different conclusion. What was observed during the mitotic process was a “permanently changing spatial mosaic. It is the mosaic-like configuration which plays a decisive role, the perception of an exogenous impulse by the cell surface may be considered as a resonance event”(Wijk 2001, p.185).

conclusion was that cell division was being triggered by a “mitotic activity of single photons of about 260nm” (*Ibid.*), a photonic flux which he gave the name “mitogenetic radiation”<sup>103</sup>.

Alexander Gurwitsch could be considered as ahead of his time, however, as during the time of his research there was not the necessary technological apparatus to support the physical experiments necessary to develop his theories.

It was only after the Second World War, with the aid of newly developed photomultipliers (PMT)<sup>104</sup>, that the observation of very weak photon emissions in the spectral range from 400-700nm was possible (Mei 1994). The first ultra-weak photon radiation observed with the aid of photomultipliers was reported in the 1950s and involved experiments with green plants (such as species of algae) (Strehler and Arnold 1951). Russian scientists carried on experimenting on plants and animal species from 1960s onward, with Konev and associated research fellows been the first to employ UV-sensitive PMT tubes to detect UV photon emission from living organisms (Wijk 2001), authenticating the classical mitogenetic work through the use of the state of the art PMT.

With the aid of this new technology, Fritz-Albert Popp was successful in providing evidence of the informational character of ultra-weak photon emission from living tissues, being the first to call the phenomenon “biophoton” in 1976 (Popp 1976a).

#### **5.4 Criticism of “mitogenetic radiation” and biophotons**

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<sup>103</sup> In spite of the fact that Gurwitsch received the credits of the discovery of mitogenetic radiation, many other reports of similar phenomenon were seen before or parallel to him. One of the cases was Scheminzky's (1916) experiment with cultures of yeasts and bacteria in which photographic plates were used to detect radiation from fermenting yeasts (Wijk 2001, p.185).

<sup>104</sup> Photomultipliers are extremely sensitive devices able to detect photon emission or very weak light in the ultraviolet, visible and near infrared range. In these detectors the signal produced by the incoming light is multiplied by as much as  $10^8$ .

The main criticism of biophotonic research is focused on the speculation of the bio-informational character of the phenomenon. This is traced back to the initial phase of the research on photon emissions from living organisms, the “mitogenetic rays” age. The great period of mitogenetic rays research lasted for about two decades (Wijk 2001, p. 185) with the news about Gurwitsch’s discovery spreading rapidly throughout the European scientific community, and subsequently his hypothesis was developed further in complementary studies. However, some experiments were unable to detect any mitogenetic rays phenomena (Bateman 1935; Hollaender and Schoeffel 1931; Richards and Taylor 1932). As a consequence, papers that disproved Gurwitsch’s theory (Hollaender and Claus 1937; Gray and Quellet 1933; Lorenz 1934) triggered the increasing discredit of research into the idea of mitogenetic rays. As a counter argument, Rahn, whom had summarised the work of Gurwitsch in English in 1936 (Rahn 1936), pointed to some experimental errors that appeared within some of the negative reports. Among of these errors was the use of young yeast cultures as a base for the testing of mitogenetic rays effect. Gurwitsch and others had observed on multiple occasions that the young stage of yeast cells “are not sensitive to external photons” (Wijk 2001, p. 185; Oschman 2006). Despite Rahn’s attempts and continued research in parts of Europe and Russia, the overall interest in Gurwitsch ideas began to decrease in Western European nations and the USA. On top of experimental problems there was also a difficulty in that most of the publications on this subject were written in Russian. This resulted in many publications and valuable data that were of limited accessibility to the scientific community of non-Russian speakers and readers (Bajpai 2006). The destruction of two major research centres in Russia and Germany during Second World War, along with the Lysenkoism in Russia (Fisher 1948), which suppressed rational scientific inquiry and led to the repression and persecution of Soviet scientists, should be taken into account when considering the slow uptake of Gurwitsch’s ideas. At the

time of this research, almost eighty years after the Gurwitsch's experiment, Russian Scientists have claimed the replication of the "impossible" mitogenetic radiation experiment (Tennenbaum 2001; Belousov 2009).

The problem regarding the authenticity of photon emission from living organisms must be divided into two specific issues (Wijk 2001). The first one refers to the question of whether or not such a phenomenon of photon emission really takes place in living organic matter. The answer for this question, based in an exhaustive number of reviews and experiments (Mei 1994; Belousov 2006a; Connor et al. 2006; Ho and Popp 1989; Kobayashi 2009; Popp 2006b; Wijk 2006a) appears to be yes. The second issue places the question regarding the bio-informational character of the photon emission. Does this ultra-weak radiation express any informational character, or is it just random noise?

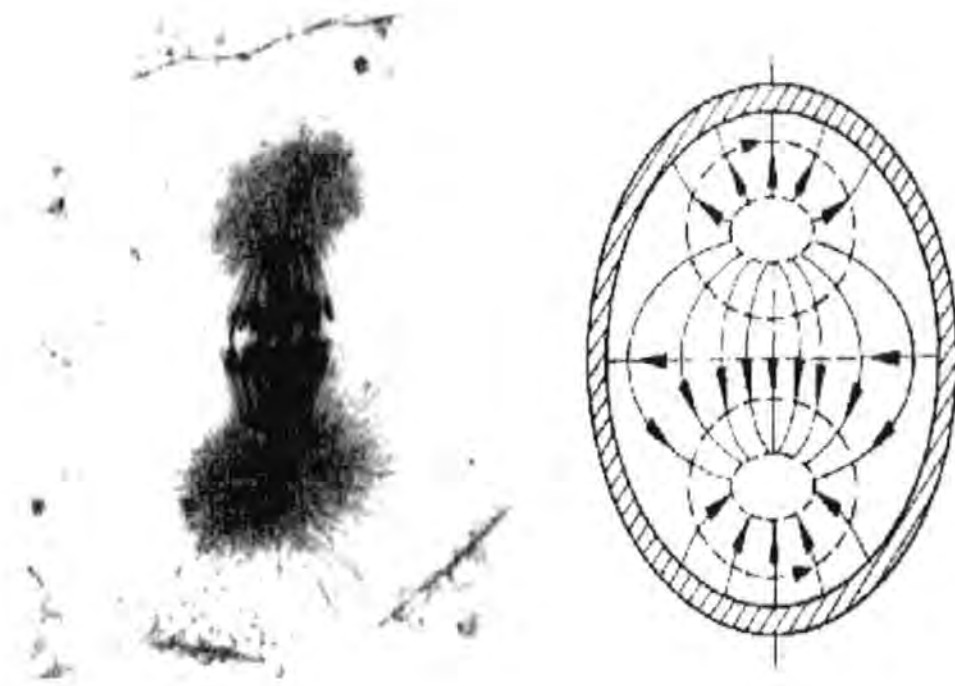
In an interview with the Brazilian electric engineer Cristiano Gallep (of the Applied Photonics Lab. - LaFA/CESET – State University of Campinas, Brazil) it was discussed that the measurements of biophotons in seedlings displayed that the intensity of photon-counts is not only far away from what may be considered noise, but also that it presented biorhythms. In a recent paper, Gallep and Santos stated:

After the fast decrease during the first hour due to light release initially stored in water and seeds, it is noted a further very slow decrease for the first 24-hour period, and thereafter the presence of 24-hours and 12-hours cycles, showing the presence of biorhythm in the light emission even with seedlings in a completely dark environment. (Gallep and Santos 2007)

In the 1970's, claims that photon radiation from living organisms resulted from excitation energy from chemical processes, and that such a bioluminescence "had no biological significance whatsoever", were postulated by the American biochemist H. H. Seliger and the Russian biophysicist A. I. Zhuravlev (cited in Popp 2003b; Bischof 2005). According to their perspective, "'weak bioluminescence' originates from 'imperfections' in metabolic activity" (Popp 2003b), which leads to the more acceptable view that "highly

reactive compounds such as radicals and oxidation reactants are the most likely candidates for photon sources” (*Ibid.*).

In turn, Fritz-Albert Popp and an increasingly large group of researchers have an alternative view. They do not deny the possibility that biochemical reactions are somehow involved in the ultra-weak photon emission phenomenon, but their investigation is set in a different manner. They ask how the well-known existence of  $10^5$  chemical reactions per cell/per second can take place without the coordination and presence of some sort of electronic excitation? To answer questions like these they look at single photons emission in the visible range and their possible displaying of spatial and temporal correlations to biological functions, such as cell growth (*Ibid.*). One of the models that has constantly been presented by Fritz-Albert Popp in his presentations and publications refers to the migration of biomolecules during mitosis. They attribute the coordination of this process, for instance, to the presence of cavity resonator waves (see fig. 33 right), which could provide the stability and guiding forces for the mitotic process. Those waves exist in the hollow space of a given structure. Calculating a hypothetical cavity resonator with transverse magnetic and electric modes and their wavelength in the optical range between 300 and 700 nm, equivalent to the size of a cell, and then comparing it with the image of a real cell mitotic process, they observed a remarkable similarity (see fig. 33).



**Figure 33:** “Mitotic figures (left) follow the field patterns of cavity resonator waves (right) under the boundary conditions of the cell under observation. The spatial pattern follows, as usual, classical electrodynamics. The time-behaviour has to be described in terms of coherent states” (Popp and Yan 2002).

As consequence of those considerations and the following correlations found between some “optical properties of biomolecules” (...) “and their biological efficacy” (*Ibid.*), Popp and his group have hypothesised (1994):

- that the original source [of biophotons] is the chromatin (DNA) of the cell which itself serves at the same time as the stabiliser of this field,
- that the spectral distribution reflects the maximum entropy of an “ideal open system”
- that the degree of coherence corresponds in the average to a fully coherent field, and
- that the biological significance has to be assigned, as Alexandre Gurwitsch was the first to suppose, to the function of a rather basic “morphogenetic” field.

The following table (see fig. 34) summarises the mains aspects of biophotonic phenomenon:



	Universal for all living systems
Emission	Continuous photon current rests only after death
Intensity	A few up to some hundred photons/(s.cm <sup>2</sup> ) $\approx 10^{-11}$ W
Spectral range	At least from 200-800 nm
Spectrum	Continuous, modes are coupled $f(\nu) \equiv \text{constant}$
Photocount statistics	Poissonian, sub-and super poissonian
Sources (s)	Not yet Known with certainty
Polarization	Unknown
Correlations	To all biological processes

Figure 34: Properties of Biophotons. Source: (Popp 2006a).

Seliger and Zhuravlev, on one side, and Fritz-Albert Popp on the other, have defined two distinct schools of interpretation of ultra-weak cell radiation. The majority of scientists working in this field subscribe to the understanding of Seliger and Zhuravlev, and approach the phenomenon based on the “physical and chemical principles of the luminescence of biological molecules and attribute the light emission to certain chemical reactions such as radical reactions and oxidation” (Bischof 2005). For this school of thought, light emitted from organisms is considered a mere waste product of metabolism. Despite such a view, their measurement methods lead to the development of instrumentation able to detect “oxidative damage in organic material” (*Ibid.*).

Contrastingly, Popp and his group have invested in the search for the biological significance of these photon emissions, which they see as meaningfully entangled to life. One of the most remarkable facts about biophotons, which demonstrate their contrast with general chemical luminescence, is that the level of biophoton emission significantly increases moments before the death of cells and stops totally when the organism dies. In a healthy organic system biophoton emission decrease considerably (Oschman 2000; Wijk 2001; Bischof 2005). Biophotonic flux also increases during the mitotic process, or when some sort of injury disturbs a given organic system; as such, this weak radiation also

responds actively to all kinds of internal and external disturbances that the whole organism is exposed. For instance, the figure below (see fig. 35) displays a biophoton image (on the left) of a wounded soybean (photographic image on the right) in which the cotyledon (an embryonic leaf) was mechanically injured with a cross-shape by a knife. In the left picture the place with the highest emission of photons corresponds with the place of the injury, as seen in the photographic image.



**Figure 35:** Biophoton image. Source: Kobayashi Lab (2009).

This behaviour is attributed to the high degree of order of light found within biophotonic phenomena, which means that biophotons originate from a coherent field with the capacity to produce constructive and destructive interference patterns, essential to their bio-communicational process (Popp 2003b; Popp 2003a). Putting this a little more simply, it could be said that biophotons work as a biological laser light.

The focus on the biocommunicative character of photons emitted from living organisms differentiates the common research approach, which subscribes to Seliger and Zhuravlev's perspective, and the integrative approach adopted by the International Institute

of Biophysics (IIB) led by Fritz-Albert Popp. The integrative approach is the main reason that this study is investigating the biophotonic model, with the aim of developing a corresponding interpretation for the aesthetics of hyperorganisms. It is understood by the argument presented here, along with other artists and thinkers, (such as John Dewey (1979), that art and life are intrinsically linked and that the living organism, understood in all its capacities to express coherence, is a source of mystery and inspiration. Paraphrasing John Dewey, in nature “[c]hanges interlock and sustain one another. Wherever there is coherence there is endurance” (*Ibid.*). To deepen our understanding of how behaviourist art and hyperorganisms have emerged from these practices one needs to pay attention to the meaning of coherence in life. Coherence is not just the quality that makes an organism (natural or artificial) function adequately (Maturana 1997) but it is also what gives it the capacity to express itself meaningfully. A theoretical model destined to understand living systems, but that does not consider the mechanisms and implications of coherence, might be incomplete.

The promise of integrative biophysics, as his approach has been named by Fritz-Albert Popp, is to support a deep biological understanding of life based on concepts of physics, redefined by theories and experiments in quantum-mechanics. The goal of these researchers is not to impose fundamental physical concepts to life; not to replace biological knowledge with laws of dead matter. Contrary to molecular biology, researchers of integrative biophysics are not focused on bioengineering life. Their epistemological and philosophical foundations lead them to believe that “the study of life can yield insights into basic physical laws more fundamental than those obtained from the investigation of non living matter” (Bischof 2003). From such a perspective they may be able to show “just how intimately we are connected with one another and with nature. How all nature is one resonating and intercommunicating whole” (Ho and Popp 1989).

## 5.5 Elements of biophoton theory

The following sections will survey the main features of the biophoton phenomenon and its biological impact. A focus will be placed on coherence within the biocommunication of living systems.

### 5.5.1 Coherence: a key concept

"The Ufaina Indians in the Colombian Amazon believe in a vital force called *fufaka* which is present in all living things. The source of this vital force is the sun. From the sun, it reaches earth and is constantly recycled among plants, animals and human beings. Each group of beings requires a minimum of the vital force in order to live, and is seen to be borrowing the energy from the total energy stock. (...) What is of importance to the Ufaina is that the vital force continues to be recycled from one species to another in such a way that not too much accumulates in any one of them, since this could deprive another of its vital force, and upset the natural balance." (von Hildebrand 1988b cited in Ho and Popp, 1989)

This cosmologic view of nature in the Ufania tribe does not come from a scientific standpoint but from a lived experience within nature. However, this wisdom is consistent with scientific evidence that nature is a "dynamically balanced whole linked by energy flow, (...) one resonating and intercommunicating whole" (Ho and Popp 1989). As in nature, living organisms are complex networks of actions being processed as a self-organising whole. Scientifically speaking, the aliveness of an organism is dependent on its capacity to:

(...) be extremely sensitive to specific cues in the environment, to transduce and amplify minute signals into definite actions. Being alive is to achieve the long range coordination of astronomical numbers of submicroscopic, molecular reactions over macroscopic distances; is to be able to summon energy at will and to engage in extremely rapid and efficient energy transduction." (Ho 1993, p. 10)

This highly coordinated process of transductive actions through space and time reduces down to a very important attribute of the living organism; coherence. In "The

Rainbow and The Worm”, Mae-Wan Ho provides a useful analogy to an understanding of what coherence means.

An intuitive way to think about it [coherence] is in terms of a symphony orchestra or a grand ballet. Or better yet, a jazz band where every individual is doing his or her own thing, but is yet in tune or in step with the whole. (Ho 1993, p. 151)

The simple action of seeing, starting with photons falling on the retina, triggers a series of molecular reactions (typically known as “*molecular cascade*” (Ho 1993, p. 6) in order to amplify the energy contained in a single photon and initiate the electric impulse of the nerve (see figs. 36, 37). This process is in part well understood, but how such a collective operation is efficiently coordinated lacks deeper explanation<sup>105</sup>. Theories about coherence in biological systems aim to provide some insight on this matter.

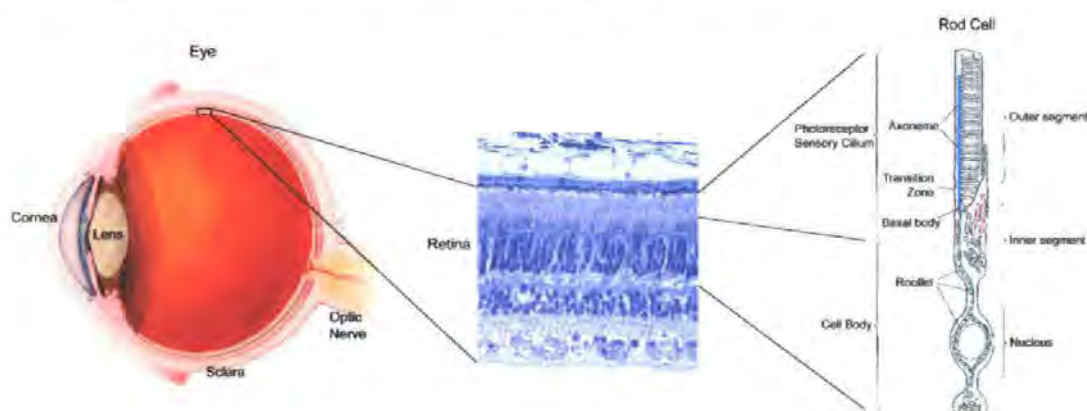
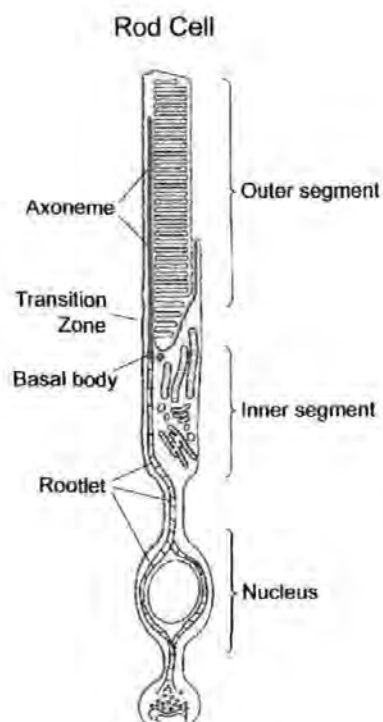


Figure 36: Rod cell system. Source: (Pierce 2009).

<sup>105</sup> One of the questions still unsolved in visual cascade reactions is addressed by Mae-Wan Ho in the following passage: “(...) the component steps [of the molecular cascade] have time constants that are too large to account for the rapidity of visual perception in the nervous system, which is of the order of  $10^{-2}$ s. Thus, it takes  $10^{-2}$ s just to activate *one* molecule of phosphodiesterase after photon absorption. Furthermore, much of the amplification is actually in the initial step, where the single photon-excited rhodopsin passes on the excitation to at least 500 molecules of transducin within one millisecond. How that is achieved is still a mystery (...)” (Ho 1993, p.7).



**Figure 37:** Diagram of a light sensitive rod cell. Source: Source: (Pierce 2009).

Many scientific groups consider the phenomenon of low-level photon emission (LLPE) as chemiluminescence, a result of biochemical reactions with the participation of reactive oxygen species (ROS)<sup>106</sup>. For this reason, remembers Vladimir Voleikov (biophysicist from M.V.Lomonosov Moscow State University), “(...) as processes with ROS participation are still regarded by the majority of bio-medical scientists as auxiliary to ‘normal’ biochemistry, LLPE which accompany these processes is looked upon as irrelevant to the performing vital functions” (Voeikov 2006). However, another view of LLPE phenomenon, rooted on Gurwitsch’s seminal work on this field, has increasingly grabbed scientific attention. According to this view:

LLPE from living matter is based on the notion that it originates from a delocalized coherent electromagnetic field that is tightly coupled to metabolic processes. In this context

<sup>106</sup> Reactive oxygen species (ROS) were usually recognised as toxic by-products of aerobic metabolism. However, recently research into plant physiology has found indications that ROS may “play an important signalling role in plants controlling processes such as growth, development, response to biotic and abiotic environmental stimuli, and programmed cell death” (Bailey-Serres and Mittler 2006).

LLPE is termed as 'biophotonic emission' and coherence theory 'assigns to the presumably phase locked and mode coupled photons from DNA a permanent regulatory activity within cells and also between cells'". (Voeikov 2006)

The agency behind the regulatory capacity of this coherent ultra-weak electromagnetic radiation of living systems is attributed to the laser-like quality of this light, i.e., a high degree of order with an extremely stable intensity (Popp et al. 1984; Belousov and Popp 1995; Wolkowski 1995; Devaraj et al. 1997; Bajpai 1999; Bischof 2005). Experimental evidences suggest that biophotons are supposed to operate as a biological laser, able to generate a network of information within the organism with regulatory effects.

#### 5.5.1.1 Coherence basic principles

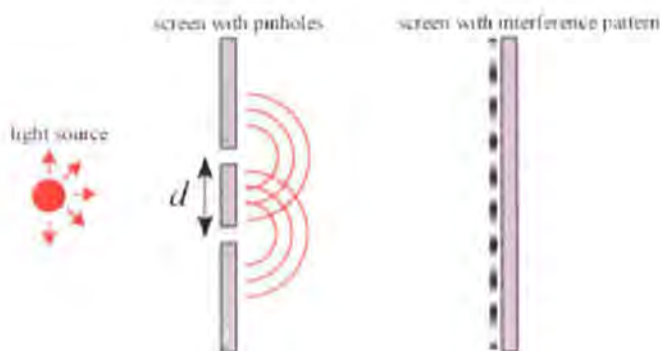
In physics, coherence refers to the capacity of electromagnetic waves to produce interference patterns. It means that if two light waves are brought together they will produce regions of destructive and constructive interferences, such as those in the figure below (fig. 38).



**Figure 38:** Light interference pattern. Source: (Skullsinthestars 2009).

The property of light to produce interference patterns was introduced for the first time to science in 1803 by Thomas Young. Through performing what became known as the

"Double Slit" Experiment (see fig. 39), it was revealed that light behaves both like particles, as observed in Newtonian physics, but also like wave.



**Figure 39:** Thomas Young's "Double Slit" experiment. Source: (Skullsinthestars 2009).

The ability to create interference patterns depends specifically on the phase relationship of the light source (Nave 2006). This phase stability is actually what is known by coherence; “the more coherent the light, the sharper the interference pattern” (Ho and Popp 1989). Another important aspect of coherence is that in such a state the parts of a system may behave “statistically independently of one another while maintaining a coherent pattern as a whole” (*Ibid.*). For instance, in a laser beam, different parts (photons) are related to each other in phase (Nave 2006). “In other words, coherence does not imply uniformity, or that every individual part or molecule of the system is necessarily doing the same thing all the time” (Ho and Popp 1989).

#### **5.5.1.2 Coherence in biological systems**

It is scientifically known that the molecules of most physical matter at ordinary temperatures present a high degree of random motions, or highly uncoordinated behaviour. It is also well known that at a temperature close to absolute zero all the molecules of a



given matter acquire a capacity of superconductivity and superfluidity, meaning that “all the molecules of the system move as one, and conduct electricity with zero resistance (by a coordinated arrangement of all the electrons)” (Ho and Popp 1989). However, it was postulated by Herbert Fröhlich (1968) that something like a “condensation into a collective mode of activity” would be able to occur in living systems, at the point that living systems, in effect, would have the capacity to act like a “superconductor” at physiological temperature (Ho and Popp 1989).

Biological systems are expected to have a branch of longitudinal electric modes in a frequency region between  $10^{11}$  and  $10^{12}$   $\text{sec}^{-1}$ . (...) if energy is supplied above a certain mean rate to such a branch, then a steady state will be reached in which a single mode of this branch is very strongly excited. The supplied energy is thus not completely thermalized but stored in a highly ordered fashion. This order expresses itself in long-range phase correlations; the phenomenon has considerable similarity with the low-temperature condensation of a Bose gas. General consequences and proposals of experiments are discussed in section 3. (Fröhlich 1968)

What Fröhlich suggested is that part of the metabolic energy is not lost as heat but is in fact stored in the form of electromechanical vibrations in the body as collective modes, which he called “coherent excitations” (Ho and Popp 1989).

The presence of coherence in a biological system reflects several of its fundamental attributes, which could be summarised as follows:

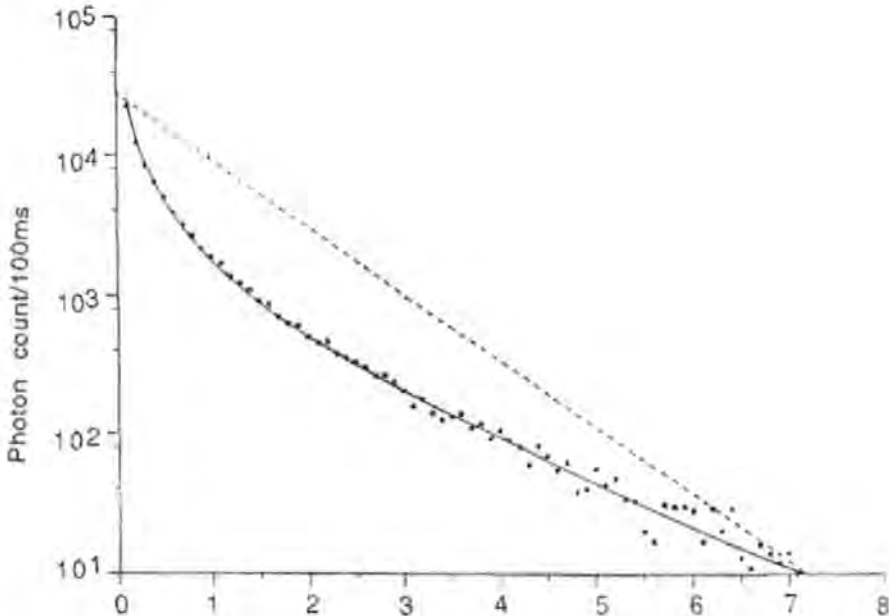
(...) high efficiency of energy transfer and transformation which often approaches 100%; the ability of communication at all levels within cells, between cells and between organisms capable of resonating to the same frequencies; the possibility for sensitive, multiple recognition systems utilizing coherent electromagnetic signals of different specific frequencies, such as for example, the organization of metabolic activities within the cell, the operation of the immune network and a host of other biological functions involving specific recognition between hormones or ligands and their receptors; and finally, the stable persistence of the working system arising from the inherent stability of coherent states. (Ho and Popp 1989)

It was Fritz-Albert Popp who provided the first evidence that coherent excitations take place in biological systems (Popp 1981; Popp 1986a). In great part this evidence is correlated to the nonlinear behaviour of this light. For instance, one of the most claimed

pieces of evidence for coherence in biophoton phenomenon is the effect of Delayed Luminescence, which will be the subject of the next sub-section.

### 5.5.2 Delayed luminescence

Delayed Luminescence was first observed by Strehler & Arnold (1951) as an afterglow in green plants that had been exposed to light illumination. The origin and purpose of this phenomenon is not known (Bajpai 1999). After a brief exposure to a weak source of light, every biological system, without exception, has been observed to re-emit light. This re-emitted light, or, in other words, the stimulated light, relaxes slowly and continuously down to “spontaneous” biophoton emission - not following an exponential curve but an hyperbolic one, as displayed in the figure below (see fig. 40) (Popp 2003b; Ho 1993).



**Figure 40:** “Hyperbolic decay kinetics of simulated light emission from a batch of synchronously developing early *Drosophila* embryos” (Ho 1993, p. 125).

The reason for this to happen is that photons are stored in a coherent way in the organism.

An intuitive way to understand this behaviour is given by Mae-Wan Ho and Popp as follows:

In a system consisting of non-interacting molecules emitting at random, the energy of the emitted photons are lost completely to the outside or converted into heat, which is the ultimate non-coherent energy. If the molecules are emitting coherently, however, the energy of the emitted photons are not completely lost to the outside. Instead, part of it is coherently reabsorbed by the system. The consequence is that the decay is very much delayed, and follows characteristically a hyperbolic curve with a long tail. (...) A coherent system stabilizes its frequencies during decay whereas a noncoherent system always suffers a shift in frequencies. That, and the capability to reabsorb emitted energy account for the stability of coherent states. (Ho and Popp 1989)

The fact that living systems are able to emit photons as a single unity characterises the new framework introduced by the biophotonic research and reveals the quantum nature of the phenomenon. As such,

[p]hotons emitted by a single unit will not be thermally distributed and will be in a pure quantum state. Photons emitted in a pure quantum state have a coherent nature and are generically called coherent photons (Loudon 1975; p. 43). Coherent photons exhibit non-classical effects. Phase, amplitude, and intensity of the classical radiation field associated with coherent photons do not fluctuate. Coherent photons, therefore, exhibit interference effects as well. (Bajpai 1999)

It is the attribute of being coherent, added to their quantum nature, that gives biophoton emissions the potential to transform and transfer information and to respond to biological phenomena, such as intracellular and intercellular communication, cell growth and differentiation and interactions among biological systems (Popp 2003b). In the interview quoted below, Popp stresses the difference informed by the quantum nature of biophoton coherence.

Classically it [coherence] means simply that you have the possibility of interference, but quantum theoretically it means furthermore that one minimizes the uncertainty product. This means not that coherent state is the ideal ordered, crystalline-like or wave-like state. For instance, a coherent state is not a monochromatic wave. It is at the same time a particle. A coherent state constitutes with some probability a particle, and with some probability it becomes a wave. It is just a rather stable unit in between these two regions. So it is squeezed between some kind of order and harmony and some kind of disorder and localization. A result of it is, for instance, that during the hyperbolic decay the coherent

photons never lose their binding to their source. This is like a yo-yo game. In extracting the photon from its source this photon remains permanently coupled to its source. Source and photon remain one unit. (Popp 1994)

Such a “squeezed state” is another important factor of biophoton. It has led scientists to speculate that such a state allows the organism to perform continuous “non-demolition measurements”<sup>107</sup> on a given photon field (Bajpai 1999). This behaviour gives to biophoton emission the characteristic of a holistic model. Such a model postulates the existence of a field structure in and around a biological system. Such a field would correspond to the immaterial structure responsible for the transferring of information and instructions. To cope with such a task it must be coherent in order to guarantee the cooperative functioning of many individual parts that are distributed in a living organism (Bajpai 1999). Despite the fact that such a holistic field has not been identified so far, “the ubiquitous presence of biophotons does suggest a possibility of identifying them as the quanta of a holistic field” (*Ibid.*). The holistic, integrative nature of biophoton emission is what qualifies it as a potential model for the immaterial dimension of aesthetic organisms. This model will be addressed at the end of this section.

### 5.5.3 DNA as source of light

Biophoton theory suggests light is stored in DNA (Popp et al. 1984), more precisely at the cell’s nuclei. This was observed when the ultra-weak photoemission stopped appearing after removal of the cell nuclei. According to Fritz-Albert Popp, DNA works as an “exciplex/excimer laser system”. It collects photons and emits them as coherent light. Technically speaking, coherent states of light originate in the DNA as a product of

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<sup>107</sup> Non-demolition measurements is the capacity of measuring a quantum system, preserving the integrity of the system and the value of the observable (Namiki et al. 1997; p.98).

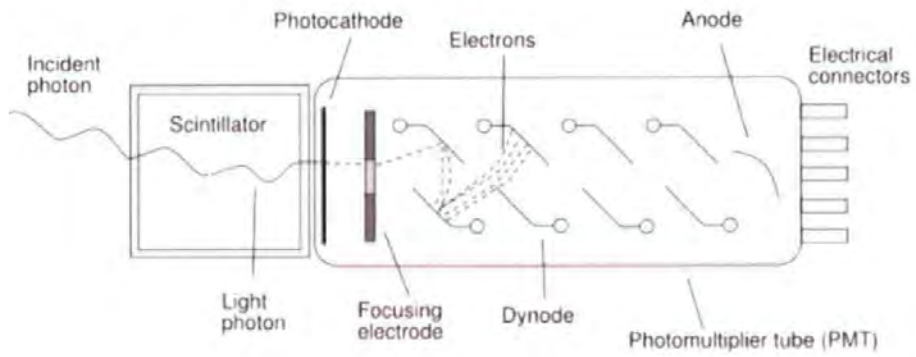
interactions between electromagnetic waves and mechanical base oscillations between photons and phonons in the DNA molecular skeleton (Mei 1994). In simple words, it could be said that the DNA works as a tuning fork vibrating in resonance with a field of electromagnetic waves in a cooperative and synergetic phenomenon.

## **5.6 Material, methods and techniques**

The following sections will focus on the instrumentation employed in biophotonic research. These sections will give an account of the two main methods of analysing biophoton emissions and their respective instruments, with special attention paid to the imaging technique. The objective of the following survey is to serve as a guiding platform for artists with an interest in this field, as well as demonstrating the variety of research activity in this subject area.

### **5.6.1 Photomultipliers (PMTs)**

Although in recent years several new devices have appeared allowing for biophoton measurement, photomultipliers (PMTs) remain the dominant instrumentation used for photodetection (Swain 2006), in part due their great sensibility and low noise. PMTs consist of an evacuated glass tube with a transparent window that is filled with a photocatode, multiple dynode stages and anode, which is organised in order to multiply, as much as 100 million times, the electric impulse of an incident photon. The corresponding signal, collected at the anode, is of enough intensity to be detected by standard electronic equipment and transformed into a measurable pulse (see fig. 41).



## photomultipliers



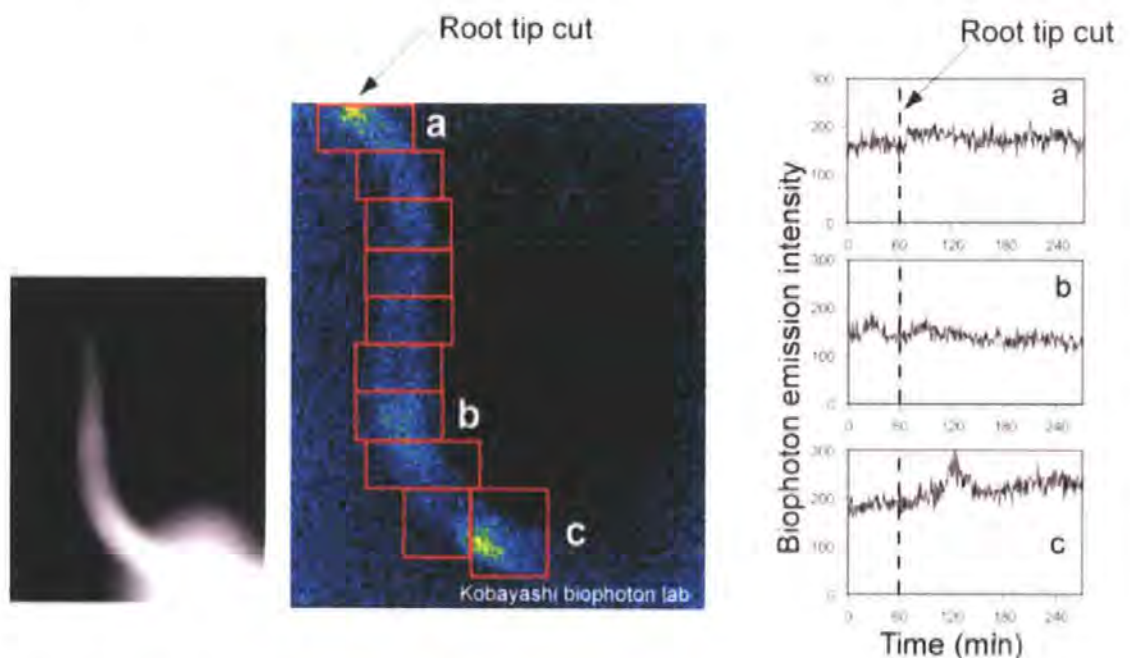
**Figure 41:** Photomultipliers (PMTs). Source: wikipedia.

In order to reduce the dark current noise that is caused by thermionic emission the photomultiplier must be cooled, which is done with the aid of housings in which a cooling liquid, such as, is used to lower the temperature of the PMT.

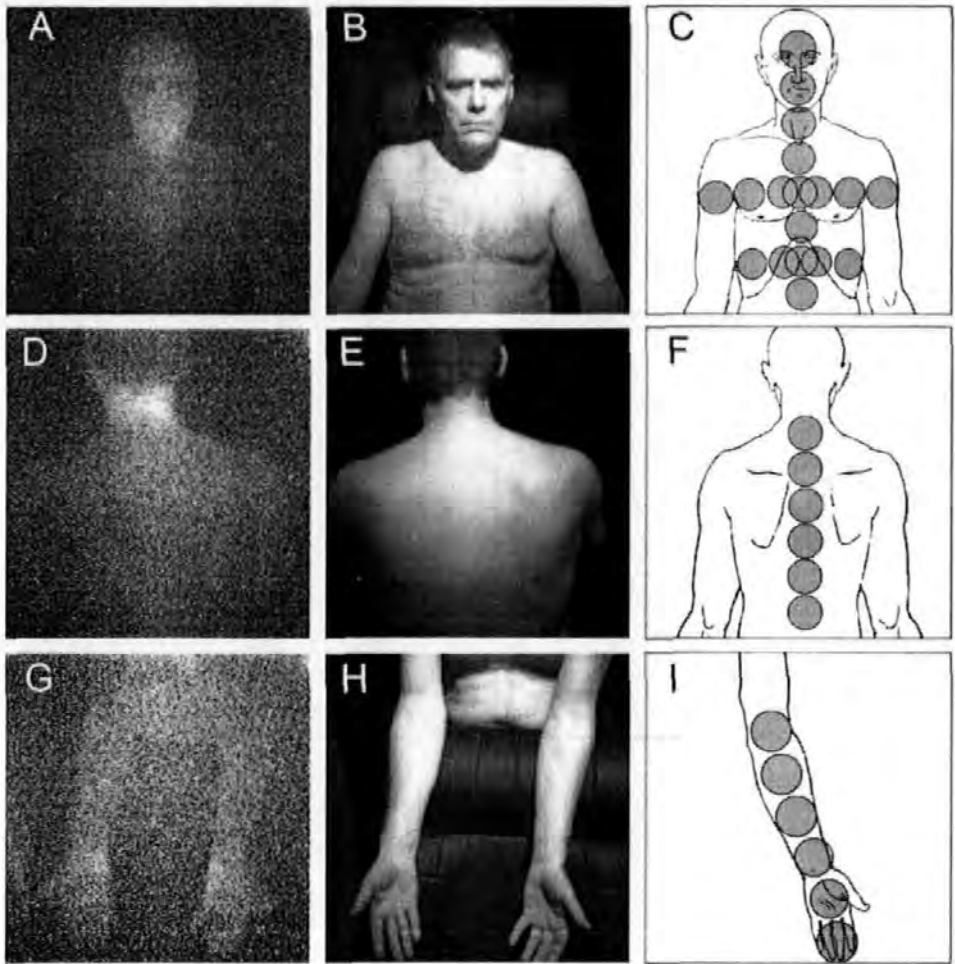
### 5.6.2 CCD imaging system

Although PMTs are the standard instrument used for photon counting, another technique makes use of highly sensitive, low-noise, cooled charge coupled devices (CCDs), normally used in astrophysics, to analyse the spatial distribution of biophoton emission. His

technology has been used consistently to image ultra-weak photoemissions from living organic matter, such as yeast culture, plants, cells, tissues, and human bodily fluids and breath (Devaraj et al. 1997; Kobayashi 2005). The use of this technique, pioneered by the Japanese school of biophoton research, has revealed correlations between patterns of biophoton emission intensity and the corresponding activity of cellular energy metabolism. For instance, the figure below (fig. 42) (produced by Masaki Kobayashi, physicist at the Tohoku Institute of Technology in Sendai – Japan) display root-tip excisions of a soybean under germination and the spatiotemporal correspondence of those stimuli on the plant, which is visible in the image as the yellower areas. In this image, the excision was made in the point labelled (a), however, after a period of time there was an increase of photon emission at site (c). According to Kobayashi, “[i]t is suspected to be the reflection of activation of cellular metabolism to repair the wounded tissue and to protect the living body” (Kobayashi 2009).

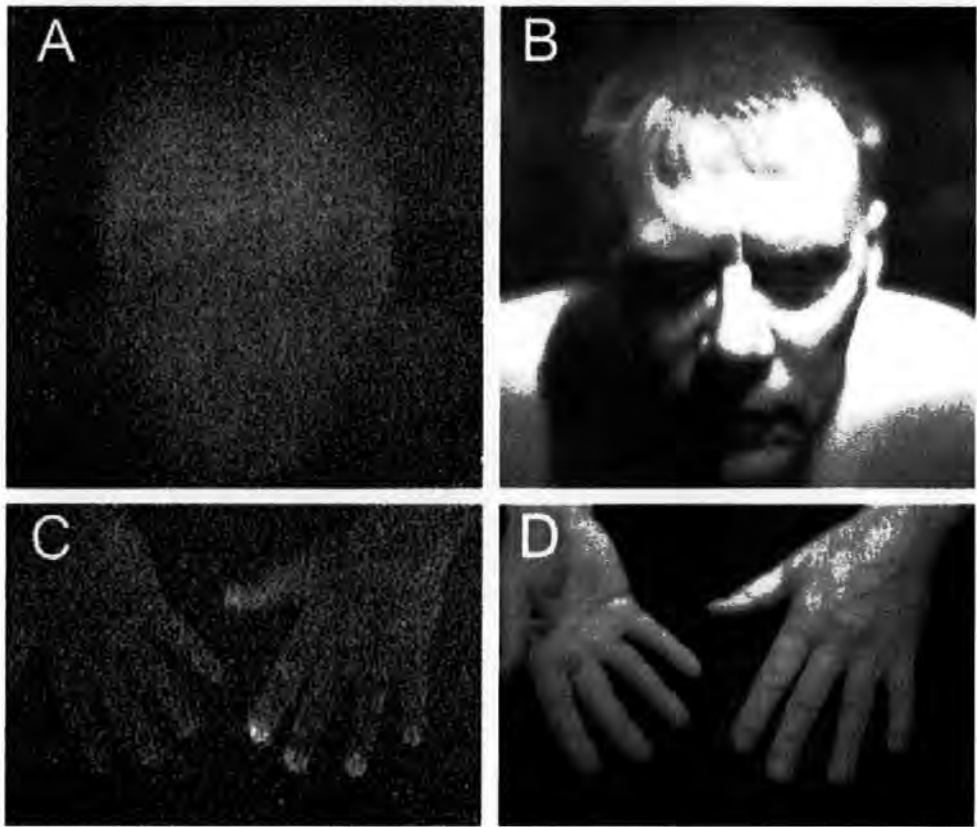


**Figure 42:** Spatiotemporal variation of biophoton. Source: (Kobayashi 2009).



**Figure 44:** The first column (A, D, G) shows ultra-weak photon emission measured with the CCD image system. The second column (B, E, H) shows photographs taken under weak illumination. The third column (C, F, I) shows anatomic spots for photo counting using movable photomultiplier. © (Wijk et al. 2006).





**Figure 45:** The first column (A, C) shows ultra-weak photon emission measured with the CCD image system. The second column (B, D) shows photographs taken under weak illumination. Source: (Wijk et al. 2006).

Roeland Van Wijk reiterates that

Neither the “pattern” of emission nor the differences between subjects reflect delayed luminescence after exposure to light prior to recording. Such is excluded by sufficient adaptation to dark room conditions prior to measurements (Wijk and Wijk 2005; Wijk and Wijk 2004). The emission pattern is also not explained by reflection of light from “high-emission” anatomical regions of the body, because emission intensity is too low (Wijk et al. 2006).

Another research group utilising a CCD imaging technique, although concerned with a different aspect of biophoton emission, is the Human Energy Systems Lab at the University of Arizona. This laboratory is coordinated by the prominent psi-phenomena<sup>108</sup> researcher Gary Schwartz,<sup>109</sup>. As a result of this meeting, a scientific exchange was

<sup>108</sup> Field of paranormal phenomena.

<sup>109</sup> In this book Schwartz reports on a series of experiments done with spirit mediums strongly suggesting that consciousness might be able to exist after physical death. The author of this thesis contacted him when attending the *Toward a Science of Consciousness* conference in April 2006.

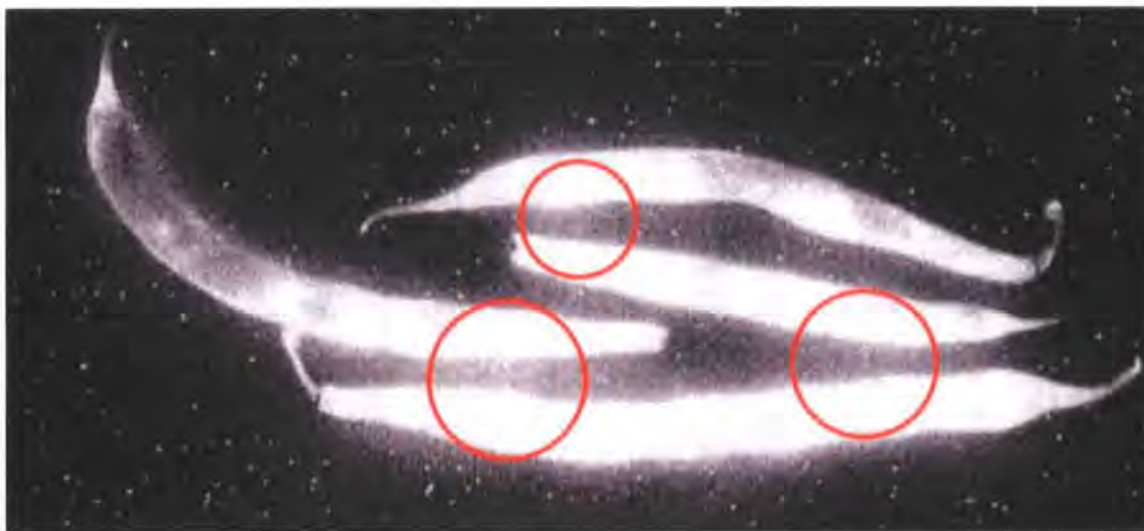
organised along with interviews with some of the researchers and collaborators involved on Schwartz's projects. Typically, these projects utilise a Roeper Scientific Biophoton Imaging System, configured as shown in the image below. The CCD device is set on top of a light-tight chamber in which living organisms are placed inside for imaging (see fig. 46).



**Figure 46:** CCD camera and light-tight chamber. © Guto Nóbrega.

Katherine Creath, from the Department of Optical Sciences and Medicine College of Optical Sciences at the University of Arizona, has been working on CCD images of leaves over the past 6 years. After studying thousands of images recorded through the CCD process, Creath began to observe “halo-like” patterns surrounding the parts of the plant (Creath and Schwartz 2005c) (see fig. 47). When the leaves are in close proximity to one another the pattern between the plants appears stronger than usual. This phenomenon has

been observed in other organisms also, such as string beans (in the image below), which were put inside the CCD/light-tight chamber system for a one-hour exposure.



**Figure 47:** “Halo-like” patterns that appear in-between adjacent string beans. Source: (Creath and Schwartz 2005c).

Creath’s study observed that the “pattern of light emitted by the plants extend beyond them, creating ‘aura-like’ structures similar to those reported by energy healers and sensitives” (Creath and Schwartz 2005c) and suggests that some sort of “resonance”, if not “communication”, between the string beans may be taking place.

Correlations between biophoton emission and the activity of healers have been another area of study for the Arizona research group. Melinda H. Connor, from the Program in Integrative Medicine at University of Arizona, has been utilising a Roesper Scientific Biophoton Imaging System to help determine the baseline characteristics of healing in Reiki<sup>110</sup> practitioners. Experiments conducted in 2004, run by Kathy Creath and

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<sup>110</sup> Reiki is an energy healing system developed in Japan by Mikao Usui during the 1920s and is practiced worldwide. As often happens with many alternative medicine knowledge, so far there is no scientific evidence for the claims. Nevertheless, the basic mechanism of Reiki is attributed to the resonance of ch'i energy fields. The ch'i is known in many belief systems, especially in Asian culture, as the energy flow of the life process. It

Gary E. Schwartz, demonstrated correlations between geranium leaves and energy healing in which a decrease in biophoton emission was noticed. In a similar experiment, run by Melinda H. Connor, geranium leaves are used as “sensors” for healing energy. This experiment was performed asking twenty energy practitioners to “intentionally” project their healing energy onto the geranium leaves, so that biophoton emission on those leaves could increase (Glow) or decrease (Healing). One leaf was set as control. Each process (healing and glowing) took ten minutes of healing activity. After this process the leaves that had been targeted by the practitioners and the control leaf were kept for 1.5 hours in the CCD/light-tight chamber system for image capturing and post-experiment measurements. The results, observed through visual and data analysis of the images, demonstrated evidence of changes in biophoton emission that corresponded to the healers’ activities. On the figure below (see fig. 48) displays the control leaf on the left. On the right side is the leaf submitted to the healing process in which the practitioners were asked to use conscious intention to heal. There is a visible difference in biophoton emission of the leaves, with the right leaf displaying less activity than the left control leaf. These observations correspond with biophoton theory and practice that has shown that healthy organisms present less photon emissions than those that are non-healthy, as they are able to store photons. The theory behind this phenomenon is going to be discussed later in this section of the thesis.

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is a fundamental component in martial arts, prominently in some Aikido schools in which all philosophy and practice is based on the acknowledgement of this energy.



**Figure 48:** On the left side is the control leaf. On the right side is the leaf submitted to the healer's intention, showing less biophoton emission. Source: (Connor et al. 2006).

In 2007, the same research group joined the author of “The Field” (McTaggart 2001) the journalist Lynne McTaggart in a long-distance double blinded biophoton experiment titled “The Intention Experiment”. For this experiment two geranium leaves with similar biophoton emission qualities were selected and placed in front of a webcam located in the Laboratory for Advances in Consciousness and Health at the University of Arizona in Tucson. The video image of the leaves was broadcast to 400 delegates<sup>111</sup> congregated in London who selected one of the leaves to intentionally make them “glow”. The leaf not chosen was set as control. The scientific team in Arizona, coordinated by Melinda H. Connor, were not made aware of which leaf was chosen. After 10 minutes of meditation the Arizona group placed both leaves in the CCD imaging system for two hours of light capture. The CCD image showed a strong biophoton emission in the geranium leaf

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<sup>111</sup> In this case the delegates were not healers but normal participants.

selected by the audience in London. According to Gary Schwartz , the results of this pilot experiment could be considered statistically significant and were being prepared for publication<sup>112</sup>.

### **5.6.3 Scientific exchange at the International Institute of Biophysics - IIB**

From July 23th to 28th 2007 the author accompanied and performed experiments at the facilities of IIB/Neuss. Part of the experimental procedures was led by Brazilian electric engineer Cristiano Gallep (from Applied Photonics Lab. - LaFA/CESET – State University of Campinas, Brazil) and concerned obtaining data for spontaneous light emission in wheat seedlings sprouts (Gallep 2007), which was to be compared with concurrent data collection for similar standard seeds in Brazil. The objective was to observe correlations between these two processes, in Germany and Brazil, under the effect of different climates. Similar photon counting measurements were pioneered in the 1950's by Colli and collaborators (1955), which observed correlations between photon emission in the visible range and the seed sample's physiological conditions.

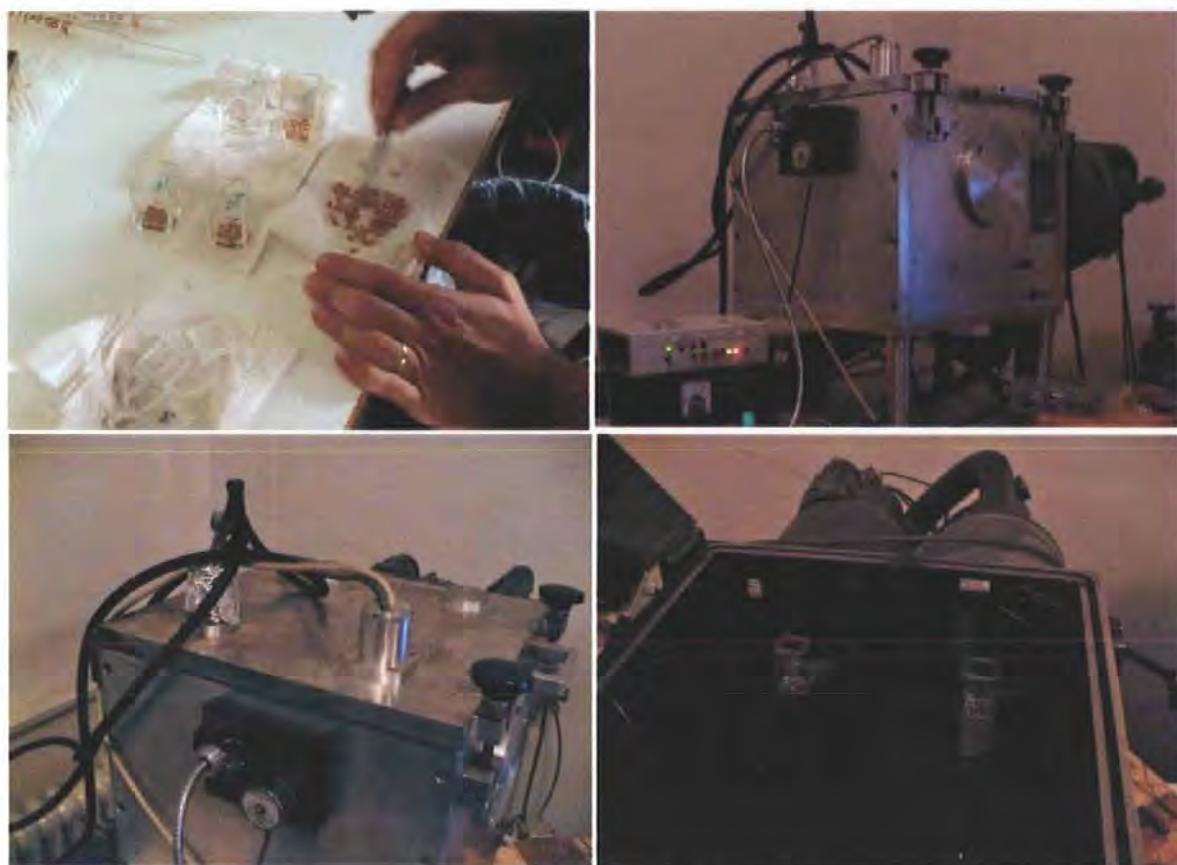
#### **5.6.3.1 Methods and Materials**

For the experiment in Germany two different types of wheat seed was used. One was commercially available in Brazil (MaisVita, id. FDL-E7C3, good until 09/03/08, called “Tb”) and the other was a biodynamically cultivated German seed (AlNatura, id. 000 7866

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<sup>112</sup> The ideas which stimulated this and a series of other experiments on this matter, involving several scientific groups around the world, can be found in the homonymous book “The intention experiment” (McTaggart 2007).

DE, good until 13/06/08, called “Ta”). Three samples of 10 randomly selected seeds were placed in a closed quartz cuvette, with 1ml of distilled water for germination. Two samples (one Brazilian and one German) were put inside the dark chamber with two PMTs (one for each group seed) for photon counting, whilst another sample was left outside as control for observation of germination performance (see fig. 49). Photon counting started after 5 minutes in the dark and was kept counting for the next three days.



**Figure 49:** Clockwise from top left: Seed selection, dark chamber with two PMTs on top and cuvettes positioned. © 2007, Guto Nóbrega.

Photo-counting during this experiment was performed after each 10 second interval. The Brazilian experiment followed a similar set up (apart from the analysis of the German seeds, which was not performed) and sensitivity of the PMT. More specific technical details of this experiment can be found in Gallep’s full report (2007).

### 5.6.3.2 Results and comments

For the purpose of clarity the discussion in this section will focus on the results plotted on the chart below (see fig. 50). The test was repeated seven times, presenting similar results. The chart displays the results of the fourth test (T4), as it clearly illustrates the correlations between biophoton emission and the physiological development of wheat seeds. Two features are prominent on this chart. The first one refers to the register of delayed luminescence (DL). When the sample seeds are placed inside the dark chamber they start releasing light stored in their system. In these experiments this process lasted typically the first 24 hours, and as such a long delayed luminescence hyperbolic curve, is visible on the chart. After DL is released the expontaneous photon emission starts to appear. This photon emission starts to increase after 24 hours from the germination of the seeds. After 60 hours another rise in photon counting is observed, now corresponding to the development of leaves and roots (paralleling the reference seeds outside the chamber). This phenomenon was observed with some variance in each of the three samples tested. This variance appears more prominently in the biodynamic seeds – possibly due to its organic qualities, systemically balanced without the interference of artificial chemical resources.

The chart below (see fig. 50) presents the total number of counts, median of the distribution and the variance between the Brazilian and German experiments. The blue and red lines correspond respectively to the German and Brazilian seeds tested in Germany. The green line corresponds to the Brazilian seeds tested in Brazil.



## T4

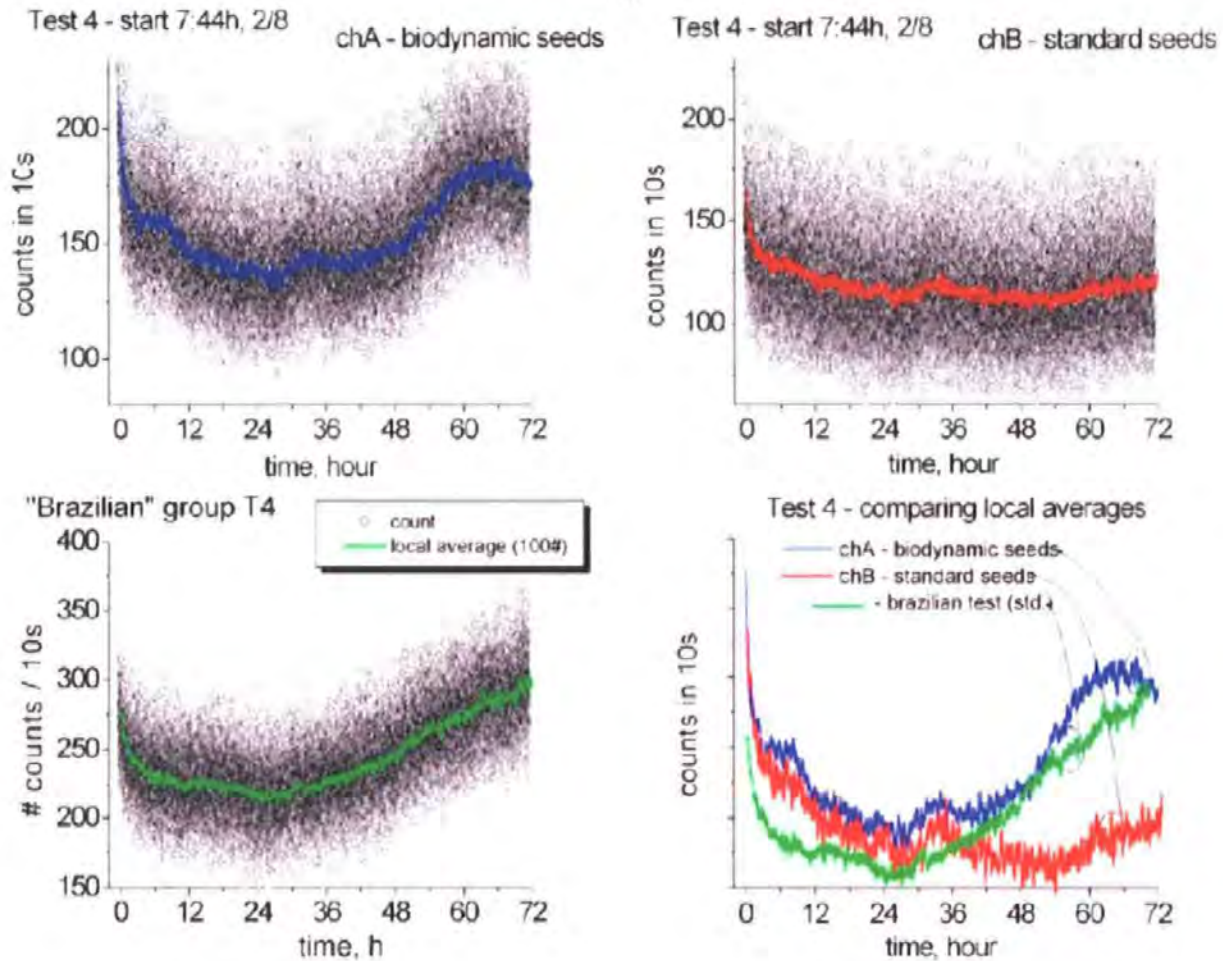


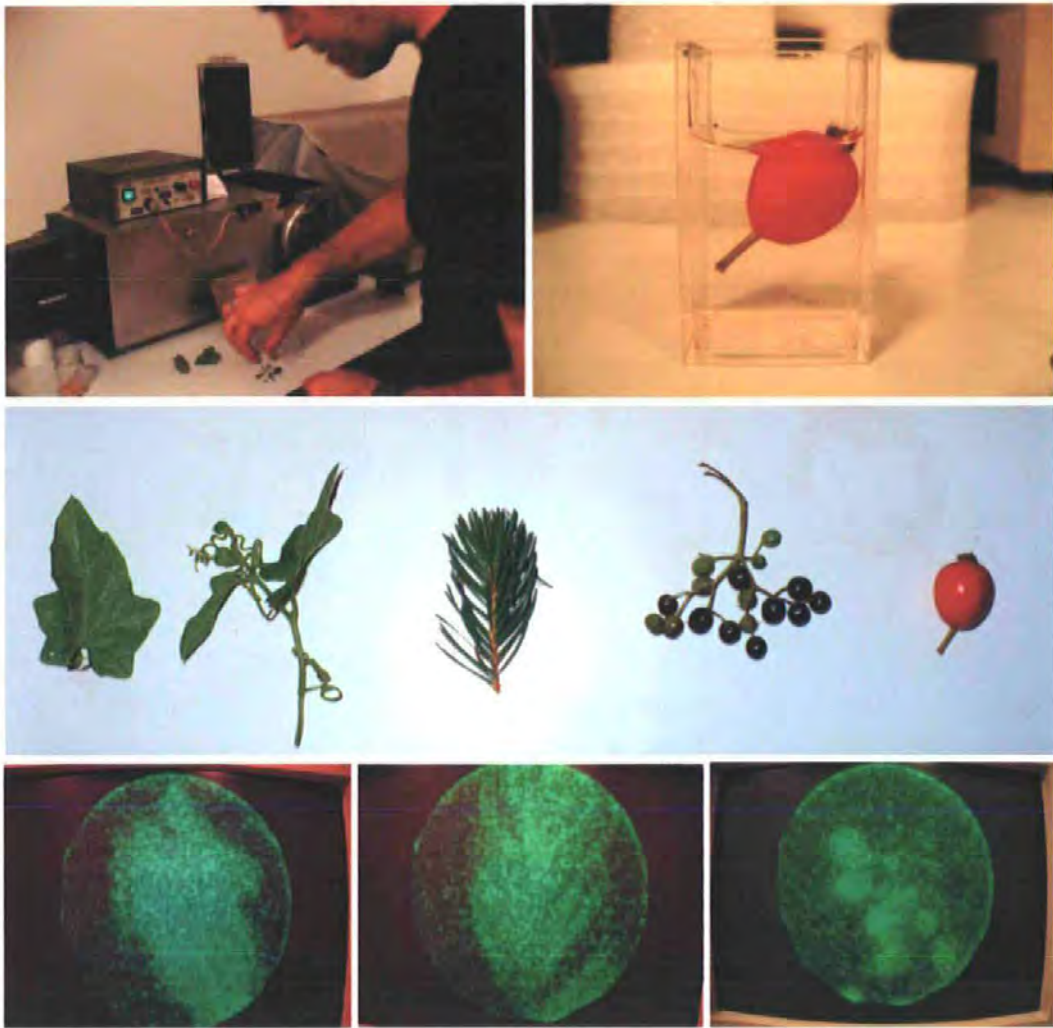
Figure 50: Photon-count series T4. Source: (Gallep 2007).

### 5.6.3.3 Practical investigation of delayed luminescence and biocommunication

The second group experiment reflects a more empirical and visual character and was performed by this author. The experiment focused on the visualisation of delayed luminescence from plants and photon emission from the *Gonyaulax Polyedra*, a bioluminescent marine *dinoflagellate*. The aim was to test the use of a CCD camera for visualising photon emissions from plants and dinoflagellates for potential aesthetic

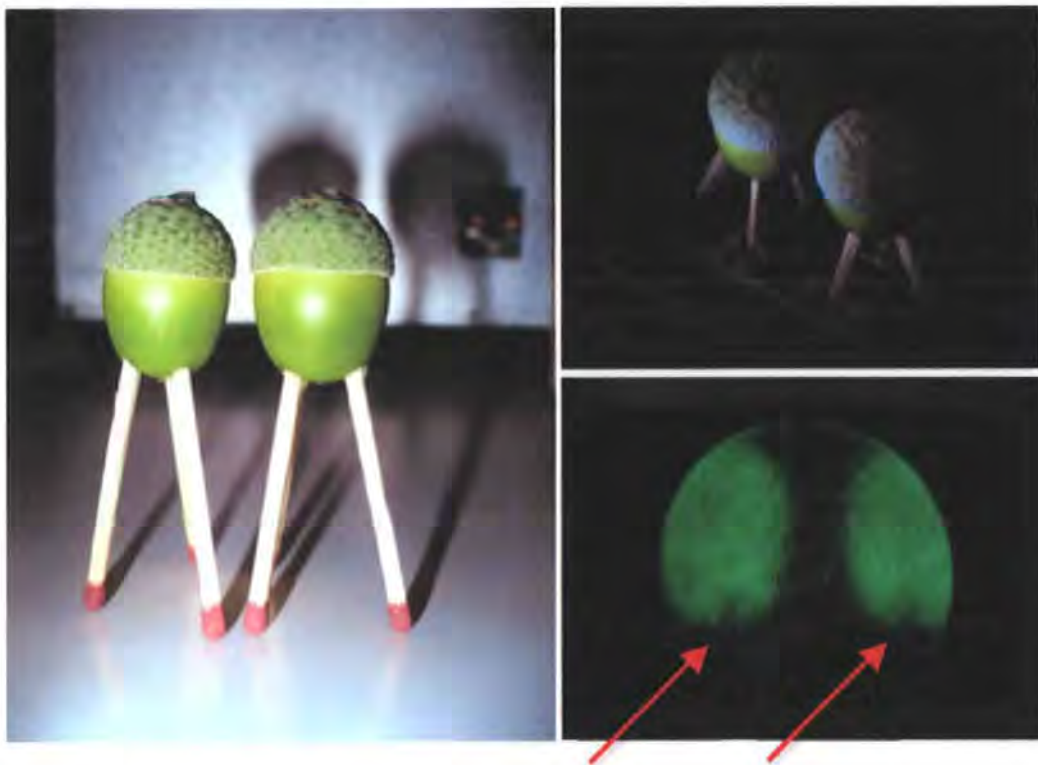
creations, whilst also to provide the author with a first-person experience of this phenomenon. Delayed luminescence occurs in living organisms, such as the leaves of a plant, following external light excitation. After being exposed to light for a few seconds photons are absorbed, stored and reemitted. Despite the fact that the delayed luminescence observed in this experiment is not from spontaneous photon emission of the living organism, which must be observed with a higher sensitivity CCD camera than was available, it corresponded to biophotonic behaviour to which it presents correlation. It is also worth highlighting that the phenomenon of delayed luminescence “is not restricted to green plants or photosynthetic systems alone but has been observed in many biological systems from bacteria to human tissues” (Bajpai 1999; Popp 1988).

The figure below (see fig. 51) present a series of tests using small plant parts collected outside the laboratory. These small portions were exposed to light for a brief period and placed inside the dark chamber for imaging. The green colourisation in the lower images is a result of the monitor that was connected to the CCD system. The system used for this experiment was a Proxitron CCD camera coupled with a multi-plate amplifier, which increases the photon signal to a visible level on the screen.



**Figure 51:** Delayed luminescence experiments. © 2007, Guto Nóbrega.

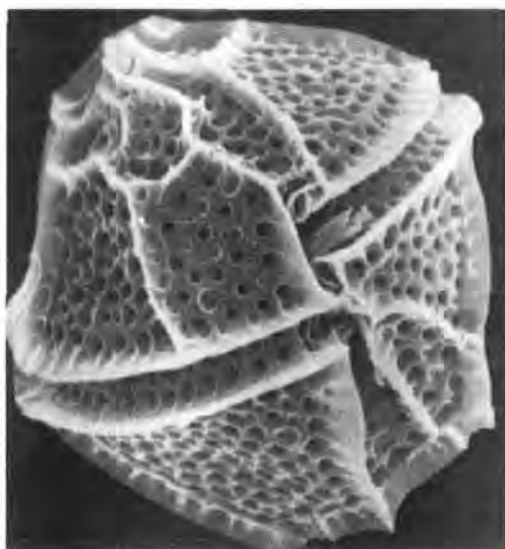
The figure below (see fig. 52) is from another experiment. This time the fruit of an acorn tree was placed inside the chamber and suspended by two matches. A light emitting diode was turned on inside the camera for few seconds to irradiate the fruits. Observe that the matches do not appear on the monitor image, only a black shadow. This is a result of luminosity being observed only from the living organic matter; the matches, as dead matter, do not emit light under the conditions of these experiments.



**Figure 52:** Delayed luminescence experiments. © 2007, Guto Nóbrega.

The final experiment was focused on the *Gonyaulax Polyedra* (see fig. 53). The objective was to test if synchronicity between two groups of *Gonyaulax* could be observed through the CCD camera system. It is known that the biocommunication phenomenon occurs in families of lampyridae, more popularly known as fireflies (Lloyd 1965). As of the completion of this thesis, it is not clear what mechanisms there are that allow this communication to take place, nor how they recognise each other, however, “a careful analysis of the synchrony showed that it cannot be explained in terms of mutual excitation with light” (Wijk 2001). Similar phenomenon occurs with some species of *dinoflagellate*, such as *Gonyaulax Polyedra*. Popp and his research group, whilst researching

biocommunication in biological systems, have observed evidence that biophoton emissions are correlated to the bioluminescent attributes of these organisms<sup>113</sup>,



**Figure 53:** Gonyaulax Polyedra. Source: (Hastings n.d.).

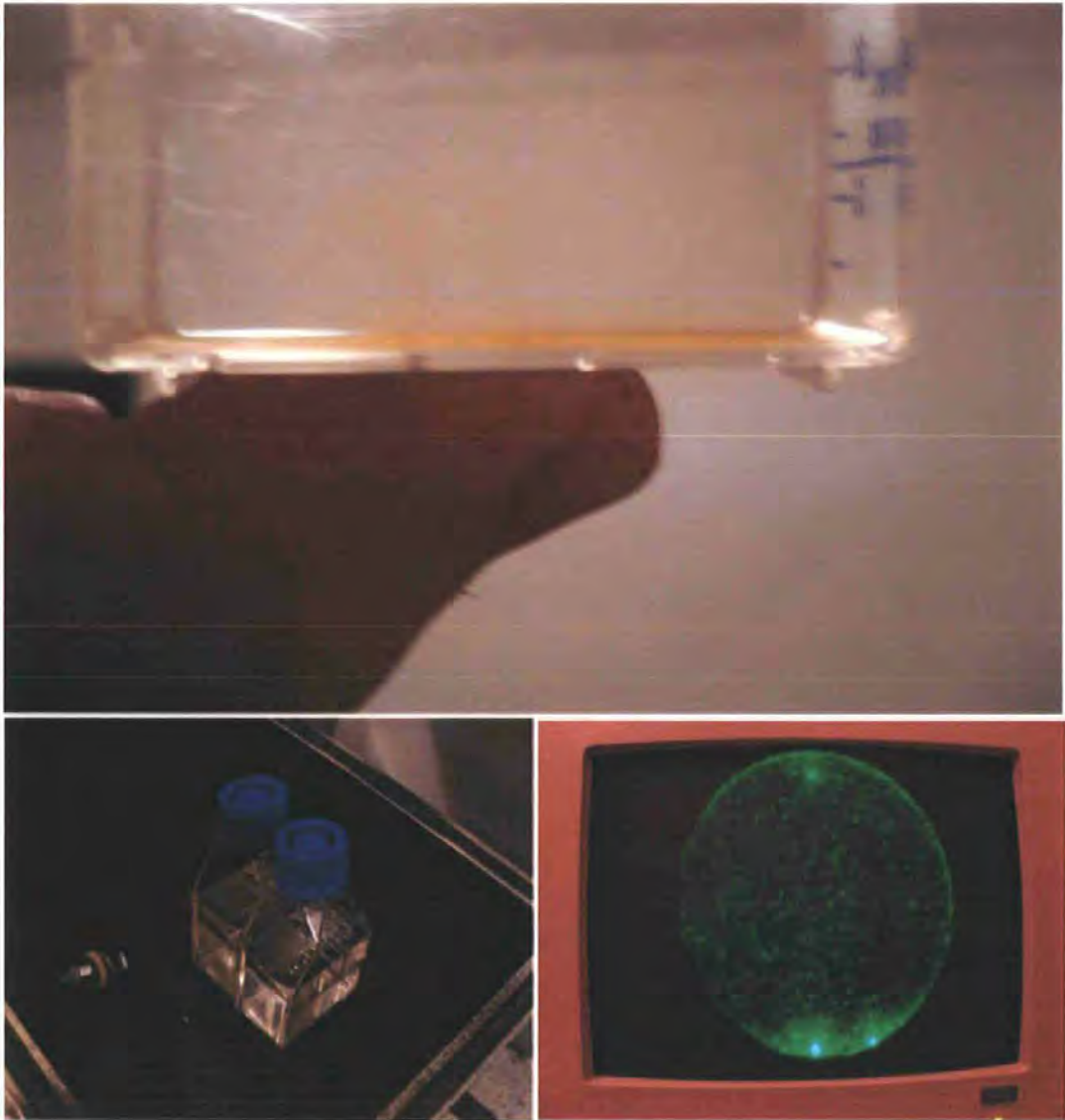
Inspired by these ideas, an experiment was set up in which two groups of Gonyaulax Polyedra were placed in the dark chamber of the CCD in order to observe any sort of synchronicity between the organisms (see fig. 54). A small piece of cardboard was used as a shutter between the two groups to allow for the control of visual and non visual contact. A noteworthy property of these organisms is their sensible reaction to vibration, to which they respond with immediate bursts of light.

Due to restrictions on the size of the cuvette available for the experiment and the use of a single camera system, and also in spite of an apparent synchronicity of flickering when the shutter between the two groups was removed, it cannot not be said that the experiment was successful in demonstrating any level of biocommunication between those groups. However, it suggests that the use of CCD cameras and the phenomenon of

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<sup>113</sup> This will be explained in greater detail in the section "Art and biophoton"

bioluminescence may provide potential for the exploration of an indirect approach to the biophoton phenomenon through relatively low-cost equipment. Due to the relative high intensity of the bioluminescent activity in *Gonyaulax Polyedra*, whose flickering can be seen by the human eye in a dark room, it was noted by the author that low lux<sup>114</sup>, low cost webcams, widely used in amateur astronomy, can be employed for monitoring the activities of bioluminescent organisms.



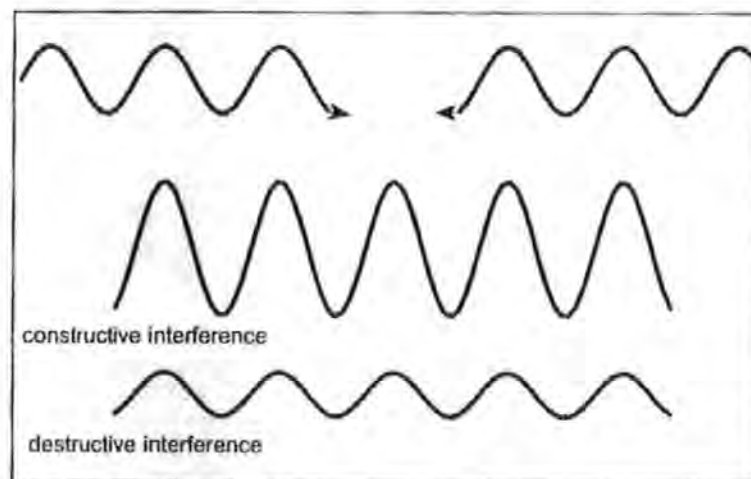
**Figure 54:** *Gonyaulax Polyedra* experiment. © 2007, Guto Nóbrega.

<sup>114</sup> Cameras with sensibility in the range of 0.0003 lux.

## 5.7 Biological implications

If the coherence of biophotons is taken into account, this series of biological phenomenon may be seen from the perspective of an integrative field model. The fact that coherent fields give rise to destructive and constructive interference patterns becomes a crucial mechanism for a possible understanding of biocommunication based on coherent field couplings. Fritz Popp has provided practical evidence for such ideas through experiments with a water flea, the *Daphnia magna* Strauss (Popp 2003b). Before continuing, it may be useful to further understand what is meant by destructive and constructive interference.

When two waves interfere, depending on the phase relationship of their source, the waves amplitude will either amplify mutually, creating “constructive interference”, also known as “super-radiance” or, on the contrary, they will subtract, leading to “destructive interference” or “sub-radiance”(Popp 2003b) (see fig. 55).



**Figure 55:** Destructive and constructive interference. (Popp 2003b).

According to American physicist Robert H. Dicke (Dicke 1954), “spontaneous reemission of absorbed light is impossible as soon as the intermolecular distance is significantly smaller than the wavelength”. Essentially, what Dicke observed was that the interactions between photons and molecules (absorption and reemission of photons) in a given coherent field breaks into two different regimes of super-radiance and sub-radiance (Wijk 2001).

Super-radiance corresponds to constructive interference of light waves cumulating up to coherent light flashes which are then emitted in relatively short time intervals. Sub-radiance is defined as the destructive interference of the light waves within the system of absorbing molecules. The result is “delayed luminescence” of coherent light waves which relax according to hyperbolic functions. (*Ibid.*)

In practice this means that “the biophoton intensity of living matter cannot increase *linearly* with the number of units, but has to follow the effective amplitudes of the interference patterns of the biophoton field between living systems” (Popp 2003b). There exists an intrinsic non-linear relationship between the coherent radiation rate of a biological system and its concentration. In other words, it is possible to say, as an example, that if the number of molecules or cells in a given coherent system is increased, the rate of biophoton emission will not rise as might be expected. The interference pattern between living organisms displays a tendency for destructive interference (sub-radiance), which results in a lower emission of photons. The opposite only occurs when the organism loses its coherence and the capacity for destructive interference. In this latter case the increase of cell density leads to a higher rate of photon emission; “delayed luminescence turns from the hyperbolic-like relaxation of normal cells to the exponential one of tumor cells” (Popp 2003b). This phenomenon states the potential application of biophoton as a functional tool for the analysis of cancer, which was the initial motivation that led Fritz-Albert Popp into this area of research.

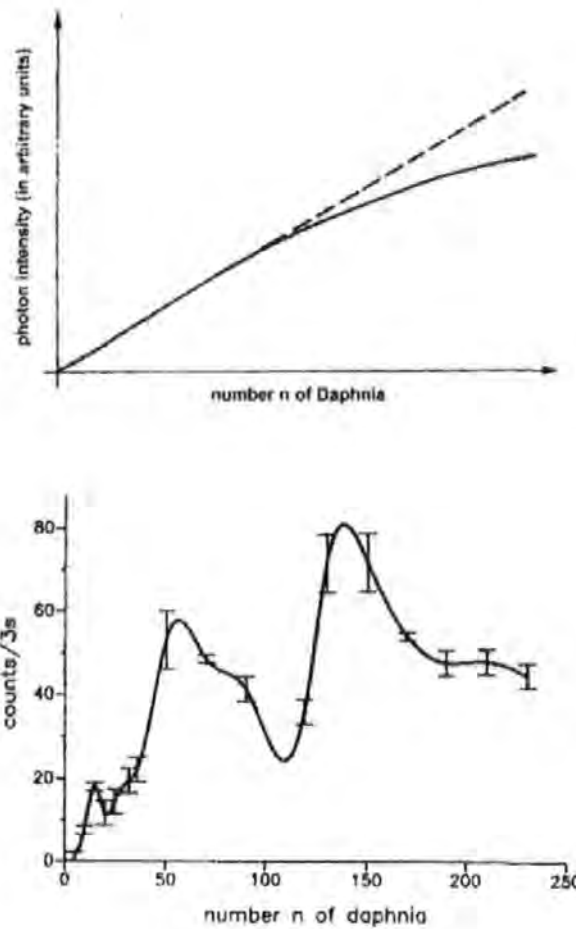


Popp examined these theories in practice. In an experiment, a group of 250 *Daphnia magna* Strauss (see fig. 56) of the same biological characteristics (female only, of the same genetics and about the same size and developmental stage) were added one by one to a quartz cuvette for photon counting with biophoton measuring equipment.



**Figure 56:** *Daphnia magna* Strauss. Source (Forschung 2009).

Popp observed that photon counting corresponded to the theory. The results of this experiment are displayed in the diagram below (see fig. 57):



**Figure 57:** *Daphnia magna* Strauss photon emission counting. Source: (Popp 2003b).

The first chart shows a linear increase in photon emission during the first stage of adaptation of the organisms, but afterwards a period a deviation appears on the chart, corresponding to the effect of sub-radiance as discussed above. Strikingly, the optimal biophoton emission (or the most efficient destruction of the biophoton field outside of the animals) appears when the number of the *Daphnia* reaches 110 unities, which corresponds to the population density of *Daphnia* in the wild (Popp 2003b).

In an interview, Marcos Bischof unfolded and speculated on the philosophical dimensions of these findings. An excerpt of the interview is quoted here in extent (the complete interview is presented in the appendices section).

if you take *Daphnia* of the same age, from a certain stage of their development, will always have the same distance between them. And this distance is also a multiple of their size. If the *Daphnia* is like this size, then the distance will be two, three times this. And there are some other interesting phenomena, which led Prof. Popp to develop a theory about this. He believes that what happens is that these animals produce a field around all of them. The field possesses a certain wavelength; the animals seem to feel best when they are exactly fitting into these waves, into the pattern of the waves, when they are in phase. The interesting thing is that when they exactly fit into this pattern then you cannot measure any field. Only if the pattern is disrupted you will be able to measure light. Popp's idea is that, and this probably applies also to human beings, we all live in a very big field which we do not perceive normally. We don't know it is there and we cannot measure it. As long we are in harmony with this field you cannot measure anything. Only if the field is disturbed then suddenly you can measure something, because there is no more harmony. And this is probably the secret of this vacuum energy, of the zero point energy. We always live in this ocean of zero point energy, and we live in a certain pattern of this field - as long as everything is in harmony, it is like nothing, the field is like it doesn't exist. But as soon as the harmony is disturbed, then you get these emissions, you can measure something, you can measure biophotons and so on. This is probably how the vacuum works, how the vacuum functions. It is a fundamental field, the foundation of everything. And we are always part of this field, and we need to be in balance so there is no tension, there is no problem. But as soon as we fall out of this balance then there will be emissions, indicating a disturbance. Because the same thing happens when we measure biophotons, for instance, of healthy people, healthy organisms or organisms that aren't ill. The interesting thing is that in the highest quality organism that is very healthy there is no emission, we don't measure anything. That means at the same time that there is a high coherence and no light comes out. We also measure biophotons from food, vegetables for instance. The highest quality food is the food that has very little biophoton emission. The fact that no light is emitted means that the lights remains inside. The body and the cells are able to keep the light, to store the light, and only then when there is imbalance the light comes out. Because the healthy cell will keep the light inside.

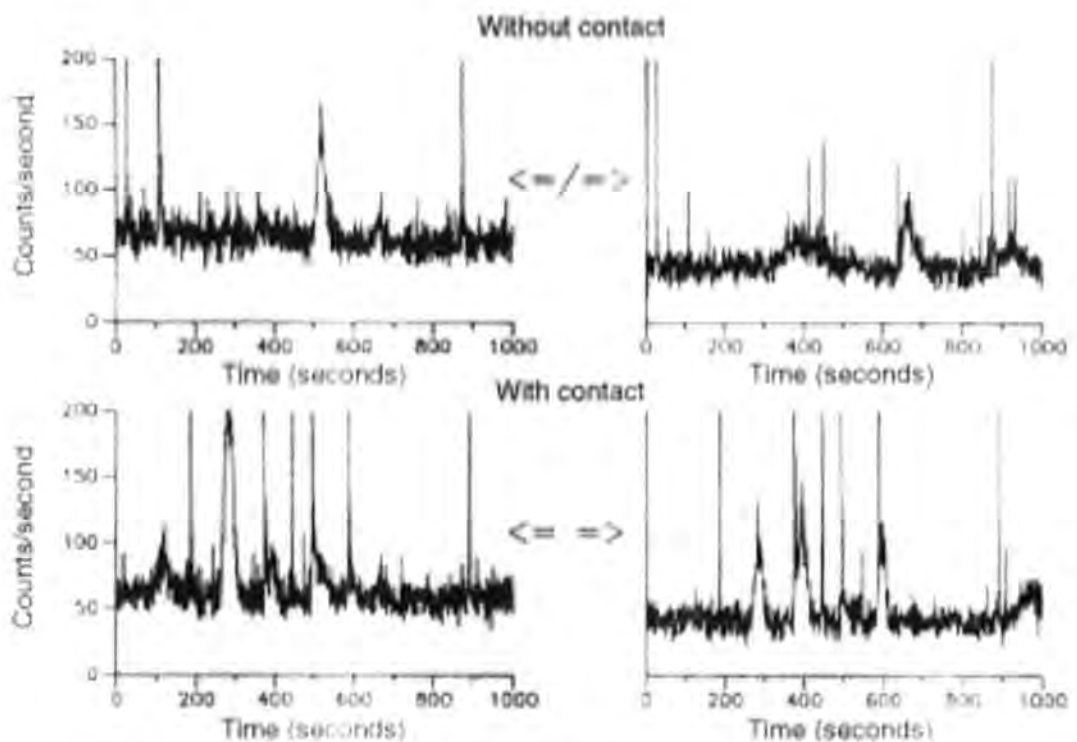
## **5.8 How biophoton interacts with art – aesthetic implications**

In the context of art, perhaps one of the most interesting experiments within the study of biophotons concerns the expression of biological coherence through music, an idea proposed and realised by Albert-Fritz Popp himself. The experiment consisted of two biological samples of the dinoflagellate *Gonyaulax polyedra*, optically separated by a mechanical shutter, so that visual communication between the two samples could be controlled. Two independent photomultipliers were configured in such a manner that the samples could be photon counted simultaneously. The output of the photomultipliers was

fed to an audio system, which output tones that corresponded to the correlations of the photon emission signal between the two samples. The chart below (fig. 58) displays the correspondence between the two groups, and the audio recording from these experiments can be accessed online<sup>115</sup>. The top section of the chart displays the period where the shutter is closed and there is no visual communication and contact (no light interconnection) between the samples. As the chart shows, random bursts of photon emissions are registered despite no optical contact between the two groups of dinoflagellates. However, when the shutter is opened the random events becomes coordinated, showing evidence of coherence taking place. In the audio sample it is possible to hear dissonances in the first stage of the experiment. In the second part, after the state of coherence between the samples appears to be established, the sound becomes harmonic. “The higher the tone, the better the correlation of signals in the two samples” (Lillge 2001).

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<sup>115</sup> Cf. <http://www.21stcenturysciencetech.com/articles/summ01/Biophysics/Biophysics.html>



**Figure 58:** Patterns of biophoton emission, Popp sound experiment. Source: (Lillge 2001).

Another example of art making use of biophotonic technology was presented recently at the exhibition "Invisible Communication"<sup>116</sup>. The curatorial focus of this exhibition was on the way artists bring visibility and audibility to the hidden network of biological information that links human beings and the natural environment. Exploring intercommunication between insects, plants and animals, the exhibition shed light on new ecologies that are made visible by the aid of biosensors and information technology. It was in this context that the artist Ando Takahiro presented his work entitled "Bio Photon: Allelopathy" (see fig. 59). He stated that:

Organisms and cells emit an extremely faint light, known as biophoton, imperceptible to the naked eye. This piece uses a photomultiplier tube (PMT) like those at the Super-Kamiokande neutrino observatory to extract the bio-photons released as a seedling sprouts. Further, the number emitted photons (light in particle form) are projected graphically, in real-time. This particular installation examines the difference in biophoton emissions between various species of plants. (Takahiro 2007)

<sup>116</sup> Held at the ICC, Tokyo - December 6, 2007.



**Figure 59:** "Bio Photon: Allelopathy" 2007. Source: (Takahiro 2008)

As has been discussed throughout this thesis, the investment in the technological apparatus as a creative platform demands experimentalism and the search for new models, so that the structure developed by the artist can unfold new metaphors and new "conversations" (Maturana 1997) with the audience. It is in this sense that the hybridisation between natural and artificial forms becomes an attractive approach to investigate the use of new technologies in artistic practice<sup>117</sup>. Exhibitions such as "Invisible Communication" appear to be suggesting that such approaches may be worthy of future attention. Unlike

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<sup>117</sup> The final part of this thesis, which is dedicated to the practice, illustrates this claim.

bioart, in which nature often stands as the living molecular source for the creative/invasive intervention of the artist (Gassert 2007; Menezes 2007; Catts and Zurr 2007; Jeremijenko 2007), many of the works presented at “Invisible Communication” try to establish a dialogue with nature through the vocalisation of subtle biological patterns. In practice such as this the boundaries between scientists and artists becomes blurred, even if the final goal is not the same. When art is no longer considered a privilege of the artist or of a specific domain, it points to its evolution into a more autonomous form. Truly artists and artworks are found not made. It might be possible to illustrate this assertion by taking another look at the examples of Ando Takahiro’s and Popp’s above work. Whereas “Bio Photon: Allelopathy” as proposed by Takahiro just scratch the surface of what is implicated in biophotonic theories, serving as an illustration for the new steps of science and technology, Popp’s experiment leads the observer into puzzling questions – such as, why do these micro organisms apparently communicate with one another? What is the implication of light in their and our inner lives? How do the crystallised boundaries that limit and separate living beings become softened by the notion that electromagnetic fields, among others, may interconnect our bodies and spirits?

When puzzling questions such as these are provoked in the mind of the observer, it is a sign that some sort of resonance between him/her, the artwork and the artist is taking place. To take an analogy from the experiment with the dinoflagellates, it is as if a shutter has been opened and the state of coherence internal to the aesthetic organism started to manifest. Art could be considered as continually provoking questions, however, the new aesthetic organisms also begin to pronounce faint answers.

It is the account for coherence and the relevance of field theories in processes of biocommunication that makes biophotonic research a strong candidate as a model for aesthetics. The following section will analyse the aesthetic organism and its mode of

existence in light of the concept of coherence and the field aspect of living organic matter. It is important to state that the analysis does not intend to rule out aesthetic experience by implementing a scientific model. The intention here is to demonstrate the juxtaposition of metaphors coming from apparently disparate domains; art, science and technology. Only when those metaphors are juxtaposed do the patterns highlighting new paths and horizons gain visibility. The goal of this thesis is to bring visibility to this map, so that future researchers can make their way.

### 5.8.1 Form and coherence

Moreover, when anyone of the parts or structures, be it which it may, is under discussion, it must not be supposed that it is its material composition to which attention is being directed or which is the object of the discussion, but rather the total form. Similarly, the true object of architecture is not bricks, mortar or timber, but the house; and so the principal object of natural philosophy is not the material elements, but their composition, and the totality of the substance, independently of which they have no existence. (Aristotle [645a] 1984)

It has been claimed in this thesis that form should be considered in the context that it was originally derived from, the field of biology.

“Form is more than shape, more than static position of components in a whole. For biology the problem of form implies a study of genesis. How have the forms of the organic world developed? How are shapes maintained in the continual flux of metabolism? How are the boundaries of the organized events we call organisms established and maintained” (Haraway 1976, p. 39)?

These questions are similarly applicable to the field of arts, the difference being that the probable answers shall not only inform the origins and mode of natural organisms but orientate processes of invention of aesthetic ones. “Form and process are essentially linked, logically and historically, in organisms” (*Ibid.*). This perspective means that instead of sustaining the prevailing dichotomy between form and process (as found in the past formalist aesthetic versus process-based aesthetics), often announced in the art and



technology discourse (Mariátegui 2007; Paul 2007), instead it is considered here as to how form and process work together in the genesis of what has been defined as a “hyperorganism”. Form shall be perceived as a result of the interactions of forces. Force precedes form, as the new science of nanotechnology has shown us (Velegol 2004). All these issues point to a fundamental question: Why and how do forces cohere in the constitution of living form? What does it mean to be a living organism?

The definition of life has been object of many (Schrödinger 1967; Dürr et al. 2002), but its essential nature is something that defeats formulas and rigid concepts. In her own attempt, Mae-Wan Ho described (Ho 1993, p. 5):

*Life is a process of being an organizing whole. It is important to emphasize that life is a process and not a thing, nor a property of a material thing or structure. (...) Life must therefore reside in the pattern of dynamic flow of matter and energy that somehow makes the organisms alive, enabling them to grow, develop and evolve. From this, one can see that the 'whole' does not refer to an isolated, nomadic entity. On the contrary, it refers to a system open to the environment, that enstructures or organizes itself (and its environment) by simultaneously 'enfolding' the external environment and spontaneously 'unfolding' its potential into highly reproducible or dynamically stable forms.*

Thus, organisms could be defined as

(...) coherent space-time structures maintained far from thermodynamic equilibrium by energy flow. This enables them to store and mobilize energy with characteristic rapidity and efficiency. (Ho 1993, p. 155)

Coherent organisms become individuals, a whole.

"(...) an individual is a field of coherent activity. (...) individualities are spatially and temporally fluid entities, in accordance to the extent of the coherence established. Thus, in long-range communication between cells and organisms, the entire community may become one when coherence is established and communication occurs without obstruction or delay." (*Ibid.*, p. 179)

These ideas link us to Simondon. What Simondon means by concretization or individuation is similar to the way organisms or technical objects become coherent. Whereas organisms are coherent by nature, technical objects become coherent through a process of invention and concretization. This process depends on states of resonance between the dynamics of internal mental and physical operations and that of the object

being created. Resulting from this insight, it could be assumed that the creation of art objects correspond to the invention of coherent wholes that are linked to the artist by their internal resonance (see fig. 61).

[T]he entire activity of the living being is not, like that of the physical individual, concentrated at its boundary with the outside world. There exists within the being a more complete regime of internal resonance requiring permanent communication and maintaining a metastability that is the precondition of life. (...) The internal resonance and the translation of its relation to itself into information are all contained in the living being's system. (Simondon 1992, p. 305)

Simondon terms the awareness to that internal resonance "affect". This allows to the argument here to infer that the creation of artworks may imply the formation of affective bonds. In that sense, it could be suggested that interaction might be reviewed in terms of affective interconnection or interaffectivity. It would not be dependent exclusively on aspects of reciprocal actions between man-machine in the technical level, but between levels of resonance, an affective level. It is not a "melding of technology and aesthetics" (Krueger 1991, p. xii) but an entanglement of aesthetics and "technicity".

We have called the creation of technologically assisted artwork hyperorganisms. Hyperorganisms are coherent wholes that could be said to be individuals continually striving against death through a process of concretization. They emerge from and respond to a field of forces (mental, physical, affective) that informs and gives them form. They could be regarded as carriers of informed energy. Hyperorganisms work, metaphorically, as a form of DNA that furnishes the aesthetic organism with its identity. Like in biophotonic theory they could be thought of as the structure that makes the aesthetic organism resonate in a certain "tune". As such, they are set in resonance with the artist and are invented in order to perform coherent "structural couplings" (Maturana 1997) with their milieu. It is only in their encounter with the observer that they come into real existence (see fig.60)

Hyperorganisms act as a whole but are formed of a combination of “elements”, which define its transductive capacity and general behaviour.

In Simondon’s terms the elements of a technical object are the “true carriers of [technicity]<sup>118</sup>, just like seeds that carry along the properties of a species and are to remake new individuals” (Simondon [1958] 1980, p. 86)<sup>119</sup>.

Individuals are produced by invention, which brings elements together to form individuals. Invention, which is the creation of an individual, presupposes an *intuitive* knowledge of the [technicity] of elements in the inventor. Invention takes place on a middle level between the concrete and the abstract, the level of diagrams, which implies an earlier existence and a coherence for its representations – those images that mask [technicity] with a layer of symbols which are part of an imaginary methodology and imaginary dynamics.

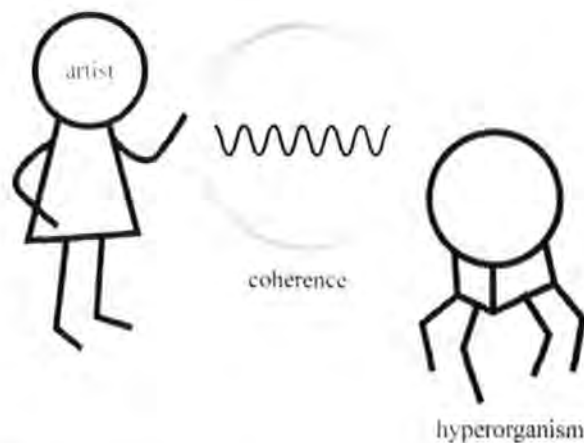


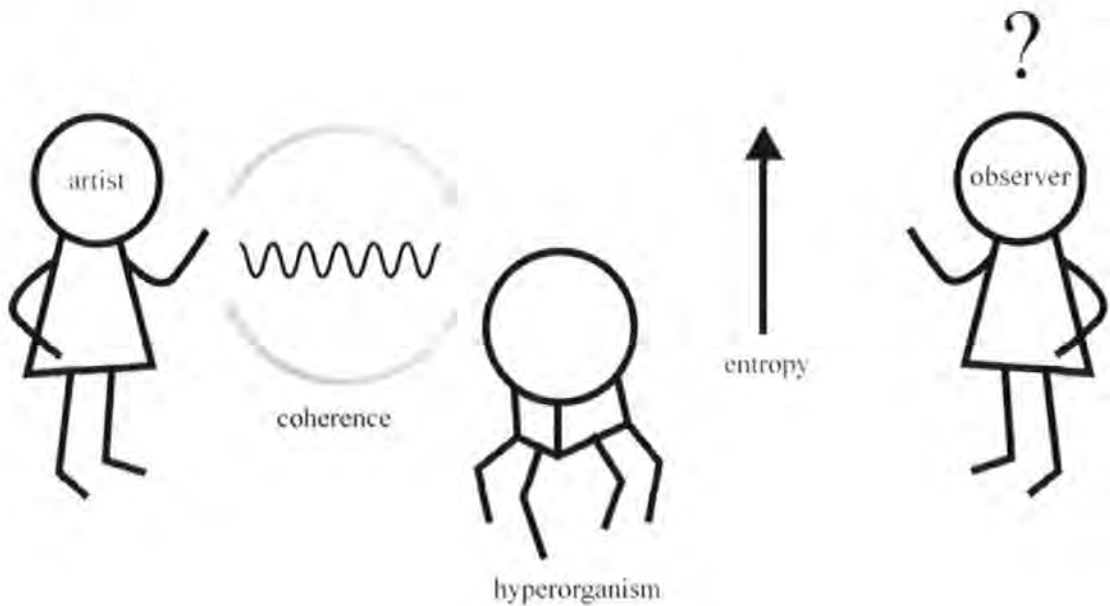
Figure 60: Invention. © 2009, Guto Nóbrega.

### 5.8.2 The observer and negative entropy

<sup>118</sup> The original French word is “technicité”. Despite the fact that the English translation have used the term “technicality” we have adopted the term “technicity” in the same way it has been translated by some scholars (Stiegler [1994] 1998; Mackenzie 2002)

<sup>119</sup> For instance, an open source microcontroller, such as “arduino” (Arduino 2006) or the codes of a programme made available on the internet, when applied in the construction of a new hyperorganism, transfer to the new one some technicity of the old. Another example is hyperorganisms that explore hybrid configurations of natural and artificial systems in its constitution (artists working with plants and technological systems, for instance). Technical solutions for the coupling of natural and artificial systems can be transferred to the body of new individuals through the use of specific elements (biosensors, PMTs, CCDs, etc). This way, hyperorganisms evolve and develop lineages of new beings in which old elements and new ones are rearranged into new configurations in order to function synergetically. It is important to pay attention to this fact as it might be used as curatorial lines in which hyperorganisms could be selected by their corresponding technicity, meaning and their essence as technical individuals.

Having established the relation between the hyperorganism and its creator, it is now possible to consider the observer. In order to do this it is necessary to understand a little more about how a living organism appears to an external observer in the perspective outlined in this thesis. From an organic point of view “(...) a coherent system is totally transparent to itself as all parts of the system are in complete, instantaneous communication” (Ho 1993, p. 167). This means that a coherent living system “*knows itself completely*” (*Ibid.* italics in the original). The level of entropy in such a system is set to a minimum. Thus, “the entropy of the living system can be expressed in terms of its deviation from coherence” (*Ibid.*). However, although a given system is coherent, to the eyes of an external observer its internal state is completely opaque, therefore highly entropic (see fig.61).



**Figure 61:** Reception. © 2009, Guto Nóbrega.

With the above considered it is possible to again look at Flusser and his definition of art as the “human activity that aims at producing improbable situations” (Flusser 2002c, p. 52).

The role of the artist is to provide potential situations that will become significant and informative to the observer. Information, therefore, is not given beforehand but is achieved by differentiation. This understanding matches the definition of information proposed by Bateson ([1972] 1987, p. 386); “the difference that makes difference”.

Knowing, in this context, could be considered a process of minimising entropy, or optimising information. To become knowing is to become coherent with the system, or as mystical traditions used to say, to become *one* as a whole.

This is exactly what is central in biophotonic research. What is fundamentally proposed by biophotonic theory, put in a very simplistic manner, is that all living systems have the capacity to establish a coherent network of communication, so that in any given organism, each cell, each molecule, is coupled by resonance in a way that the whole system “knows” holistically and has immediate information about all of its parts. Biophotonic research understands that the bond that integrates the whole organism is made of a field of light. Diseases and incoherencies cause the breaking of that bond. When the internal couplings of a living system are broken, light stops being stored on the cells and becomes visible. At that moment the whole body works in unison in a process of healing. If this scientific concept is transported to the domain of art, a strong metaphor is formed that reframes art in terms of living organisation.

Artworks in many ways are strange creatures; at first glance they are never completely understood. Flusser would state that they are informative as they stand out of habit. However, if entropy is taken as the measure of the level of disorder in a physical system then we are led to a paradox; artworks being out of order means that they are actually highly entropic. This paradox may be the result of an old dichotomy: object-subject.

(...) western science is premised on the separation of the observer as disembodied mind from an objective nature observed.<sup>(...)</sup> This is also the origin of the subjective-objective dichotomy, which when pushed to its logical conclusion, comes up against the seemingly insurmountable difficulty that in order to have sufficient information about the system, one has in effect to destroy it.

The dichotomy of object-subject prevails when an observer isolates him/herself outside of the observed. However, it is the argument of this thesis that artworks are not systems to be observed this way. They may be strange creatures but they are part of the observer's knowledge already, since the artwork was invented by the artist with the observer in mind as a fundamental component of its scheme. The artist is the very first observer of his/her creations. They are strange in the same way diseases are strange to one's body, but in fact are manifestations of the body when it is found out of its balance. Only by overcoming the object-subject dichotomy can an artwork be fully experienced. The artwork is born as a strange corpus part of a potential aesthetic organism. It is strange in principle as it is found out of coherence with the observer. Alike to what occurs in biophotonic phenomena, it is an organism calling for attention; its physical presence manifests intensely. If it calls for the observer's attention, as it may, an exchange takes place. The role of the observer is to engage in that conversation. As the dialogue develops both organisms get to know each other and become a coherent whole. At that moment the level of entropy within the artist-artwork-observer system decreases, whilst the level of information maximises (see fig. 62). Just as biophotonic theory predicts, when the state of coherence of an organism is established the level of communication is optimised. This is the moment when system and observer becomes one. This may explain the state of immersion and timeless flow reported in spiritual and aesthetic experiences (Zics 2008). The reason for this occurrence is due in part to another important component intrinsically related to coherence: time. As living organisms are a "coherent space-time structure" (Ho 1993, p. 167), Mae-Wan Ho suggests that "time itself is generated by process, specifically by the incoherence

of action” (*Ibid.*). During the experience of coherence, time collapses or disappears completely.

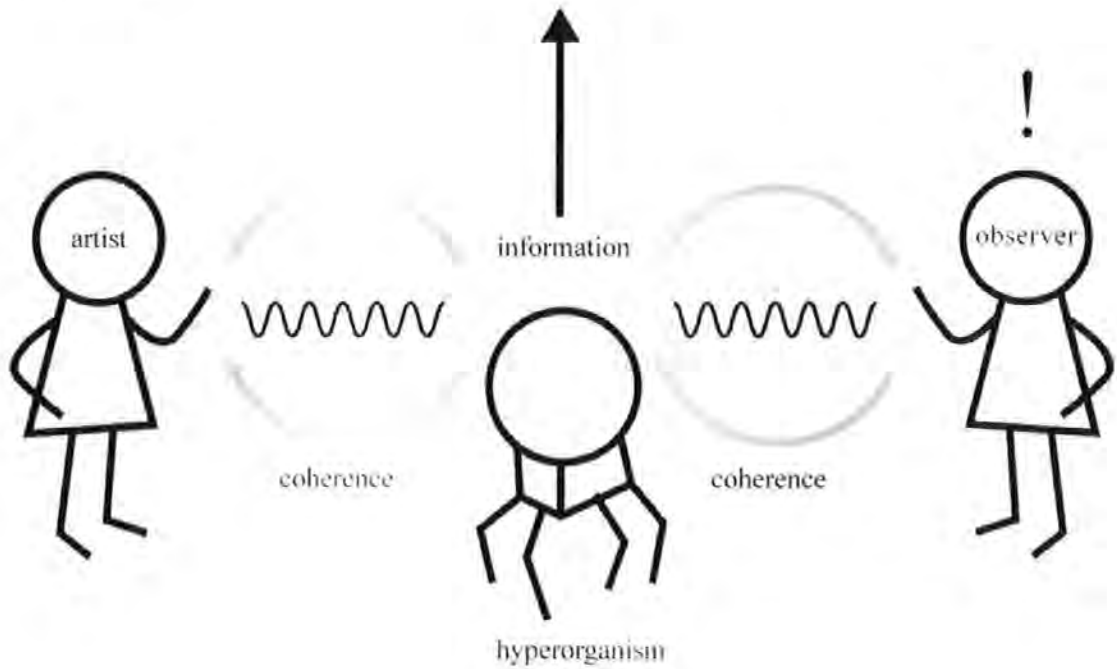


Figure 62: Information. © 2009, Guto Nóbrega.

### 5.8.3 Art as a field phenomenon

It is now possible to conclude the analysis suggesting that similarly to a living system, the aesthetic organism emerges from a process striving towards coherence. The boundaries of the aesthetic organism are delimited by the field of coherence, which manifests from the interplay of three subsystems: the artist, the artwork and the observer. We have called this field an “integrative field” or, an iField (see fig. 63), and the artwork a hyperorganism.

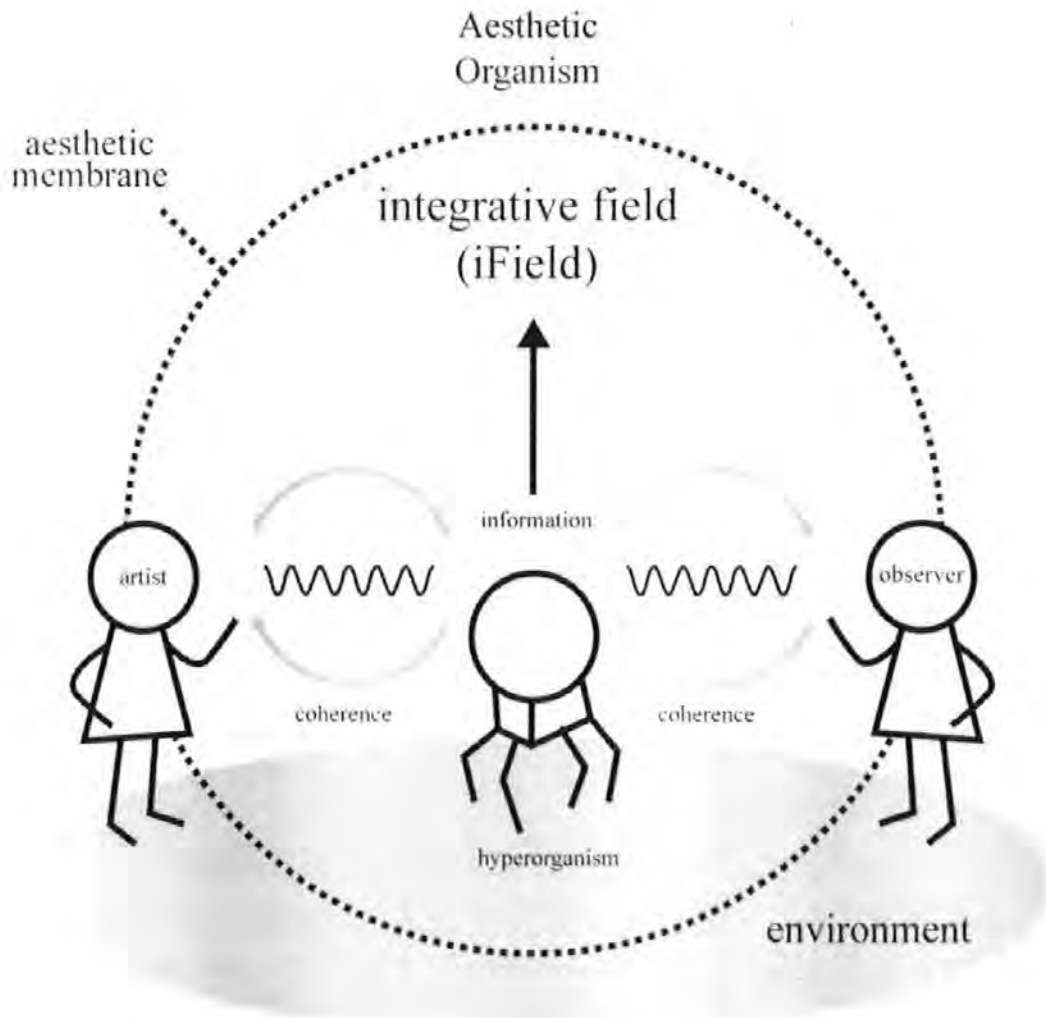


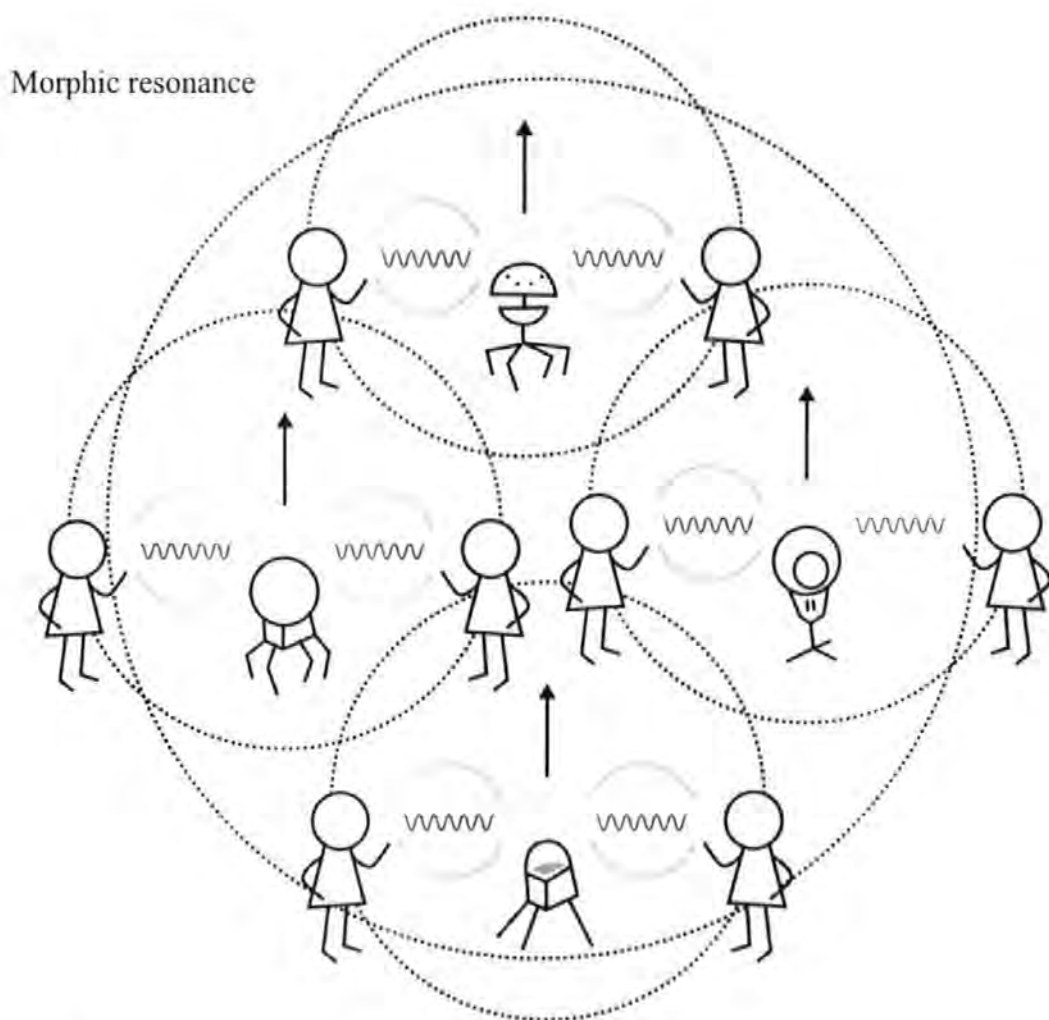
Figure 63: Integrative field – iField. © 2009, Guto Nóbrega.

The iField is what provides the form of the aesthetic organism, defining what has been defined as its “aesthetic membrane”. The aesthetic membrane represents the space-time in which the aesthetic organism manifests. It is not dependent to the physical environment, despite the fact that it resonates to it through the subject matter<sup>120</sup>. The aesthetic membrane defines the morphology of the aesthetic organism in affective terms. It is the dimension in which all resonances manifest and the immaterial link between the artist, the hyperorganism and the observer occurs. If the memory of the hyperorganism is allocated in the elements that constitute its body and transductive capacities, the memory of

<sup>120</sup> Cf. section “The subject matter”.



the aesthetic organism is stored within the iField and it is transferred by resonance of its membrane. Therefore, it would not be inadequate to say that the memory of the aesthetic organism is transferred by morphic resonance (see fig.64), a concept sympathetic to the idea suggested in the 1980s by the British scientist Rupert Sheldrake.



**Figure 64:** Morphic resonance. © 2009, Guto Nóbrega.

Morphic resonance finds its roots in the work of organicists and the concept of “morphogenetic fields” developed by Alexandre Gurwitsch (1922) in Russia, Hans Spemann (1924) in Germany and Paul Weiss (1929)<sup>121</sup> in Austria and explored further by the British

<sup>121</sup> Cf. book “Principles of Development”(Weiss 1939).

biologist Conrad Hal Waddington with the idea of the existence of active “individual fields” in the formation of organs (Waddington 1957).

The principle of morphic fields was further developed by Sheldrake in his book “The presence of the past” (1988), in which he claims that the nature of all things are informed by fields. Those fields, which he called “morphic fields”, he defines as the “field of information”.

Morphic fields, like the known fields of physics such as gravitational fields, are non-material regions of influence extending in space and continuing in time. They are localized within and around the systems they organize. When any particular organized system ceases to exist, as when an atom splits, a snowflake melts, or an animal dies, its organizing field disappears from that place. But in another sense, morphic fields do not disappear: they are potential organizing patterns of influence, and can appear again physically in other times and places, wherever and whenever the physical conditions are appropriate. When they do so, they contain within themselves a memory of their previous physical existences. (Sheldrake 1988)

Biological field theories became quite accepted as working models in the period from 1920 to 1950 (Bischof 1998, p. 136). They worked as a counter-movement to the mechanist-reductionist programs. However, the affirmation of the field of molecular biology, supported by the Rockefeller Foundation, established a more reductionist approach with an emphasis on molecular and physicochemical aspects of physiology, which orientated researches from 1950 onwards (Kay 1993).

Sheldrake’s theory of morphogenetic field and morphic resonance has little support in the mainstream science. One of the first critics of his theory, Sir John Maddox, published in September 1981 an editorial in the prestigious scientific journal *Nature* damning Sheldrake’s book “A New Science of Life: The Hypothesis of Causative Formation” (1981). In the editorial he wrote:

Sheldrake’s argument is an exercise in pseudo-science.(...) Many readers will be left with the impression that Sheldrake has succeeded in finding a place for magic within scientific discussion—and this, indeed, may have been a part of the objective of writing such a book. (Maddox 1981 cited in Freeman 2005a)

In support of the openness to radical innovative thinking, the editorial received many letters of protest, one of which was from the Nobel Laureate quantum physicist Brian Josephson. On the letter he stated that “the fundamental weakness is a failure to admit even the possibility that genuine physical facts may exist which lie outside the scope of current scientific descriptions.” (Josephson cited in Sheldrake 1981, p. 21)

Whereas in the field of biology the theory of morphic resonance is regarded as pseudo-science, in the field of art it provides a strong metaphor and a robust conceptual model to understand the evolution of aesthetic organisms. In order to gain acceptance in the scientific community the theory of morphic resonance must reveal the “occult” chains of cause and effect that informs matter. In the model for aesthetics as proposed in this thesis the invisible forces that engender the appearing of new hyperorganisms and the consequent morphogenesis of aesthetic form are felt as affective fields. As in the morphic fields proposed by Sheldrake, they could be defined as “non-material regions of influence extending in space and continuing in time”, and that “they are localized within and around the systems they organize”. In fact, this could be a definition of art. Like a morphic field an aesthetic organism does not disappear completely but remains potentially organised as patterns of influence that manifests here and there. This is how its memory is defined; aesthetic organisms “contain within themselves a memory of their previous physical existences”.

Hyperorganisms are processes of coherence. Unlike natural organisms they move towards coherence via a process of concretization. As part of an aesthetic body, subject to the interactions of the observer, their state of coherence is always fluctuating in a metastable fashion. This is what gives them their liveness. Hypoerorganisms become alive by manifesting their capacity to shift between states of coherence and incoherence.

It has been understood and argued in this thesis that coherence is the nuclear point in which aesthetic organisms can be pushed forward, where the development of creativity can achieve the highest degree of freedom. Now we are able to answer the question in regard to Flusser's claim of experimentalism. What does it mean, in practice, being experimental with the apparatus?<sup>122</sup> To be experimental with hyperorganisms means to push the boundaries of their level of coherence; is to introduce new models to inform their prosthetic bodies, shifting their transductive elements in order to produce new modes of individuation.

Since the very beginning of the present research we have thought of dialogues between natural and artificial forms. These possible dialogues are in truth microcosmos of our own condition, as human beings sharing hybrid environments with artificial systems. These ideas have pervaded the whole development of the present study and has subsequently informed its practice. After the extensive discussion presented herein we see clearly the potential of hybridisation. Hybridisation means the potential for mutual exchange of knowledge. The hybridisation of natural and artificial forms implies the crossing over of coherence from different nature, the inborn coherence of natural organisms with the invented coherence of artificial ones. This takes the form of a mutual symbiosis. The artificial organism has a great deal to learn with the coherences of natural *poiesis*, and, if technology is a way of revealing, it may disclose patterns still concealed within the mysteries of nature (see fig. 65).

These ideas presented and concluded upon here were the motivation for the art practice that is documented in the next and final part of this thesis.

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<sup>122</sup> Cf. section "Being experimental. Hacking the apparatus programme"

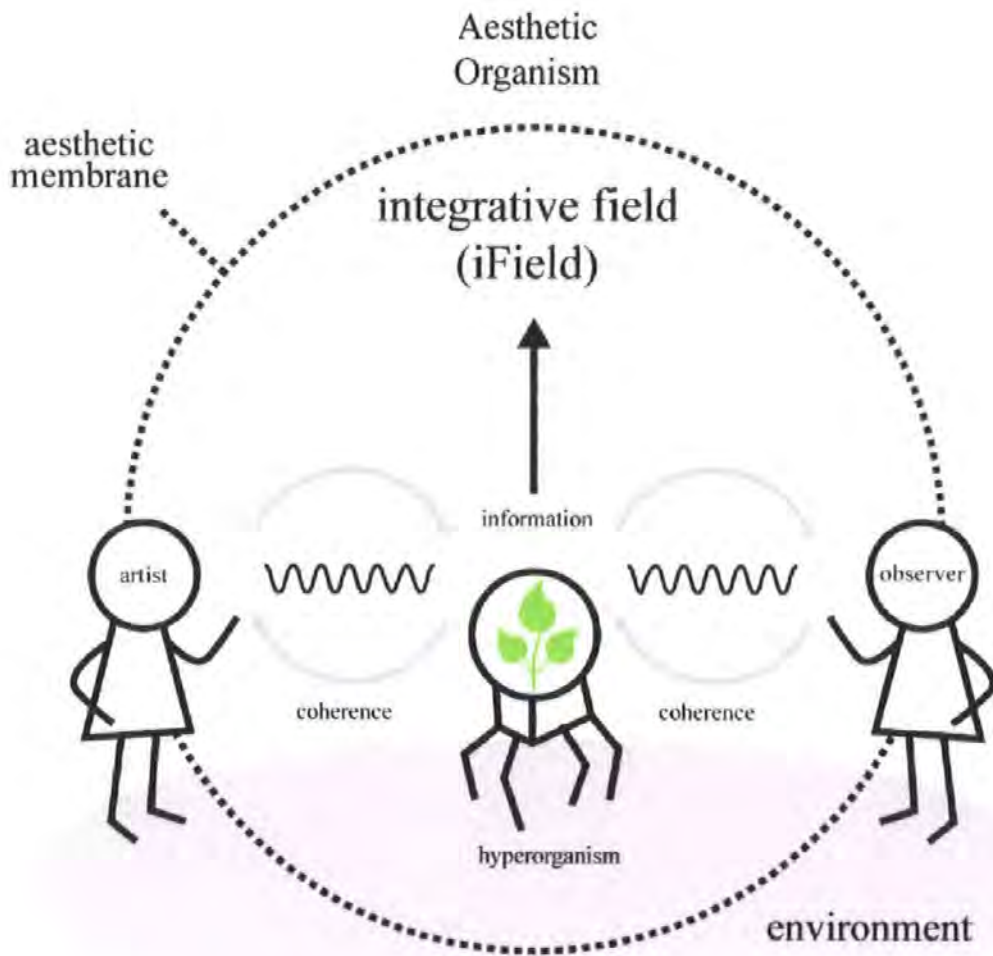


Figure 65: Leaves System. © 2009, Guto Nóbrega.

## PART IV: NATURE

### Leaves System - Practical Work

#### 6 Leaves System project

“Leaves System” is the umbrella title for a series of art projects that encompass the body of practice developed in the course of the present study. This section reports on these

practices through the two sub-sections “Background” and “Works”. “Background” introduces research in the study of plant life and their biocommunicative capacities. This study is focused on the work of Sir Jagadish Chandra Bose and Cleve Backster. The aim is to inform the conceptual influences that permeate the practice, whilst also introducing the belief system through which plants are considered in the approach outlined throughout this thesis. Following the argument developed throughout the thesis, Leaves System intends to explore new models of communication between plants and humans through hybridization of plants and artificial systems.

The section “Works” describes the projects “Equilibrium”, “Happiness”, “Ephemera” and the major work “Breathing”. All these works are presented on the DVD that comes with the thesis, and can also be accessed on the website <http://www.gutonobrega.co.uk>.

## 6.1 Background

“Leaves System” is an art project investigating notions of biocommunication. The goal is to develop a dialogical<sup>123</sup> system in which plants play a fundamental role as sensitive agents. This research has been oriented by the cultural analysis of technology and the way it has hybridized with natural organisms, blurring the boundaries that delimit natural and artificial domains. This collection of work uses physical computing to explore plants as biotransducers for the creation of aesthetic experiences.

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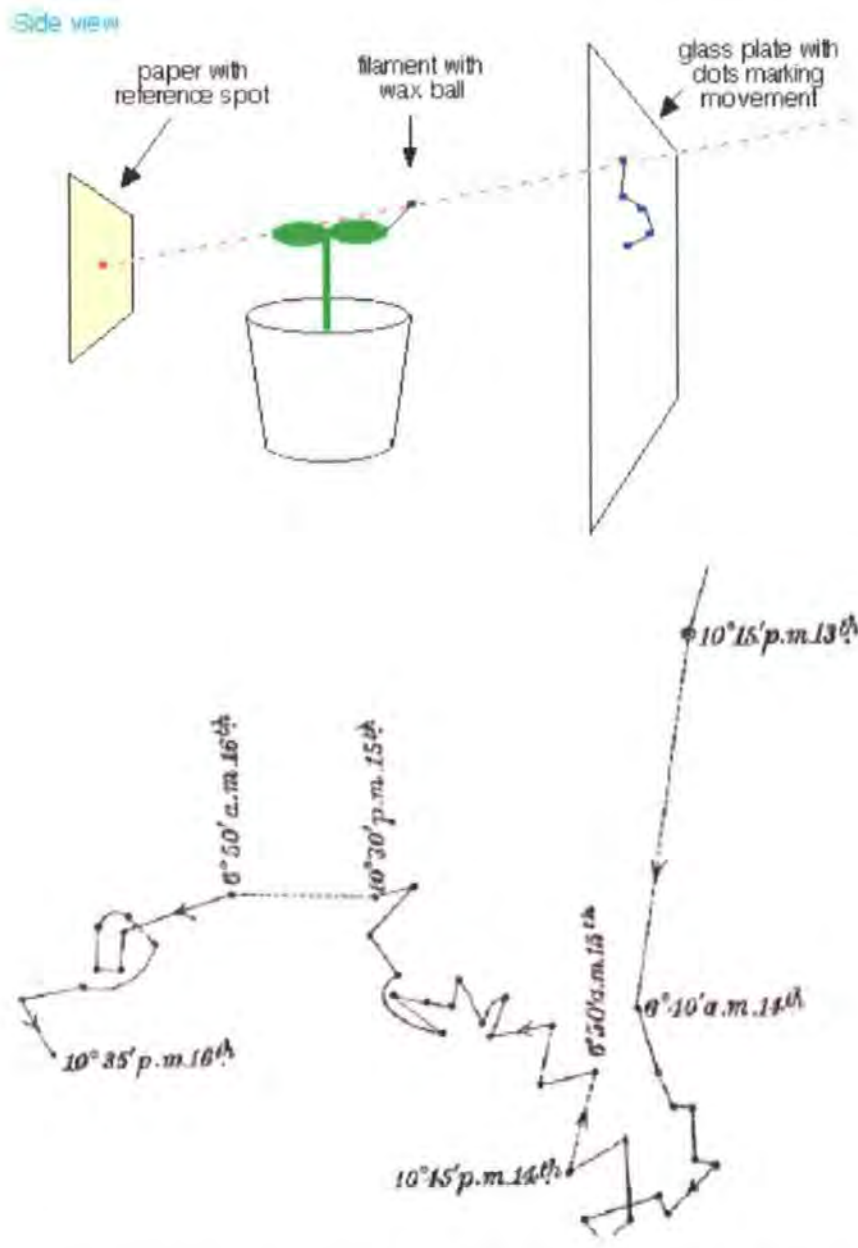
<sup>123</sup> Dialogical in the same sense of the term *dialogism* as proposed by Eduardo Kac in reference to his works of art created with telematic media. As he states, such works are “communication events in which information flows in multiple directions. These events aim not to represent a transformation in the structure of communication but to create experience of it”, and proposes “that new insights can be gained by examining artworks that are themselves real dialogues, that is, active forms of communication between two living entities.” (Kac 2005)

### 6.1.1 Why plants?

Plants have been around us since the very beginning of humanity, predating human beings on earth. Plants are living organisms but due to their apparent lack of movement humans tend to take them for granted as passive natural objects. However, for more than one century it has been known that plants are in constant action. In “The Power of Movement in Plants” (Darwin 1880), Charles Darwin describes a hundred experiments he performed on numerous species of plants that demonstrated, through relatively simple procedures, the plant’s movement<sup>124</sup> (see fig. 66).

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<sup>124</sup> “Darwin accomplished this by attaching one end of a thin glass filament to a plant with a small bead of black wax, or a small paper triangle attached to the other end of the filament. Several inches behind the plant he placed a piece of paper on which he drew a small dot. He then placed a piece of glass several inches in front of the plant. By viewing the plant through the glass with one eye and moving his head until the wax ball was in the line of site with the dot on the paper, he could then mark a dot on the glass such that it was in line with the reference spot and the wax ball. He would then record the time next to the mark he just made. By observing the plant the same way at different times, it was possible to detect even very small movements by observing the displacement of the dots drawn on the glass. By changing the distance between the plant and the glass, it was possible to change the magnification of the movements. It is interesting to notice the aesthetical value of such method.” (Hangarter 2000) The drawings made by Darwin were possibly one of the first results of such a collaboration between a man and a plant (see fig. 68).



**Figure 66:** Darwin's plant experiments and the resulting drawings. Source: (Hangarter 2000) (See description in footnote n°116).

Nowadays, through the use of powerful digital cameras and interval recording functions, it is simple to create time-lapse movies of plants, enabling the perception of these lively beings around us. In some manner, this may be thought of as putting on a new pair of glasses that allows us to view nature in a different way. Nevertheless, what does this say about the sentience of the plants? Do plants feel? How do they respond to the environment? Brazilian popular culture feeds the belief that plants are instruments of protection and cure.



Some cultures in Brazil consider *Sansevieria cylindrical*, known in Brazil by the popular name of *Espada de São Jorge*, as house “protectors” (like a natural safeguard for your home). When arranged side by side it blocks negative energies – is what says the popular belief. *Ruta graveolens*, the scientific name of *Arruda*, is considered an efficient agent against envy and is used for purification and defence. It is a common expression to say that people who appreciate gardening are “green thumbed”, meaning that such people are attuned to plants and vice-versa. These concerns raise the following questions. If plants can feel, do they have a nervous system? What does science have to say about it? The pioneering work of Jagadish Chandra Bose may provide some illumination to this discussion.

### **6.1.2 The work of Sir Jagadish Chandra Bose**

Sir Jagadish Chandra Bose (1858-1937) is considered the first Indian scientist to be recognised internationally. He achieved results on a level rarely attained in physics, vegetal and animal physiology and psychology (Geddes 1920). Bose may be considered one of the first biophysicists “before biophysics exist as such” (Bischof 2003). In his research Bose intersected various domains of knowledge, anticipating a hundred years in advance the interdisciplinary mode of enquiry that is popular at the time of this thesis. Bose was born in Mymensingh in Bengal and attended St. Xavier’s, a Jesuit College in Calcutta where he received a B.A diploma. Completing this diploma allowed Bose to travel to London to study medicine. For health reasons, however, he was forced to stop his studies and decided to leave London and take science at Cambridge, where he was awarded a scholarship and

graduated in natural science in 1884. With this education Bose returned to Calcutta and was appointed Professor of Physics at Presidency College (Gueddes 1920, p. 28; Parry 1997).

J. C. Bose's research career could be outlined in two main fields of inquiries: physics and plant physiology. His investigations into the physics started in 1884 and were centred on the work of the German physicist Heinrich Rudolf Hertz (1857-1894). Hertz managed to produce electric waves, which were predicted mathematically by James Clerk Maxwell (1831-1879) twenty years before, and demonstrated similar properties between electromagnetic and light waves. Hertz applied wavelengths of 66cm, however, Bose carried out experiments at wavelengths as short as 5 and 6mm (nowadays commonly known as microwaves). In a small laboratory in the Presidency College in Calcutta, he managed to produce experiments involving waveguides, horn antennas<sup>125</sup>, dielectric lens, polarizes and semiconductors at frequencies as high as 60GHz. Bose performed investigations into wireless transmissions<sup>126</sup> before Marconi, improving the form of the "coherer", the first device used to detect radio signals in wireless telegraphy<sup>127</sup>.

Working to refine the sensibility of his receivers, Bose came across the phenomenon that came to be christened the "electric touch" (Geddes 1920, pp. 72) or "contact-sensitiveness". In discovering this phenomenon Bose also observed that the molecular structure of all metals changed under electric radiation, causing the material to present what he called "fatigue"<sup>128</sup>. Carrying out successive experiments between 1900 and 1902, Bose showed that metal, animal muscles and plants present similar reaction curves under the effects of fatigue, stimulus or depression when caused by electric waves or

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<sup>125</sup> A horn antenna is used for the transmission and reception of microwave signals.

<sup>126</sup> In 1895, in a public lecture in Calcutta, Bose demonstrated the capacity of electric rays to travel from one room to another 75 feet away from the radiator. To perform this experiment he assembled a set of transmitters, antennae and receptors that could be considered the embryo of what would turn out to be modern wireless telegraphy, developed by Oliver Lodged and Marconi.

<sup>127</sup> "Its operation is based upon the large resistance offered to the passage of electric current by loose metal filings, which decreases under the influence of radio frequency alternating current." (Jenkins 2006)

<sup>128</sup> Today, this is well-known as the mechanic fatigue of metals.

poisons. These findings opened a newly-widened field of research<sup>129</sup> that led Bose to investigate similarities between the behaviour of inorganic and organic matter. In a paper read at the International Congress of Physics in Paris, for the first time Bose presented scientific research that “compares and parallelises the responses to the excitation of living tissues with those of inorganic matter” (Geddes 1920, p. 88). Bose believed in continuity between the living and nonliving. In the paper presented to the Congress he concluded:

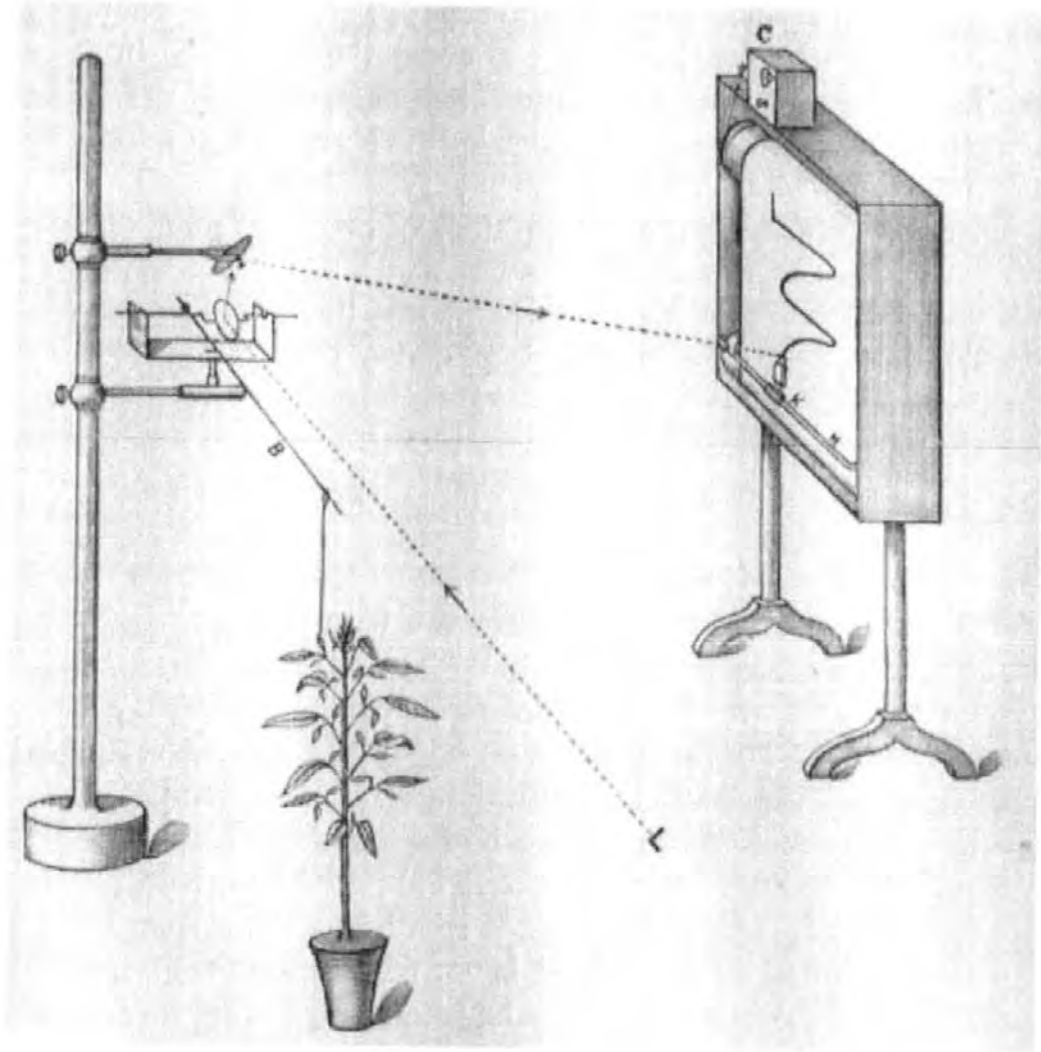
It is difficult to draw a line and say, ‘here the physical phenomenon ends and the physiological begins’, or, ‘that is a phenomenon of death matter, and this is a vital phenomenon peculiar to the living.’ These lines of demarcation would be quite arbitrary. (*Ibid.*)

During the completion of this research, Bose was gradually crossing from the field of physics to biology. From 1903 onwards his research was completely devoted to plant physiology. Bose’s main inquiry was whether or not ordinary plants and their various organs were sensitive to mechanical or other kind of stimuli. At that time, it was best known among plant physiologists that *Mimosa Pudica* responds to irritation by a sudden fall of the leaf as a result of pulvinus contracting. Bose noted that the contraction, despite being small, was magnified by the leaf-stalk. Thus, he wondered if such contraction would be present, but not perceivable, in ordinary plants. To test his hypothesis he worked on a magnifying device that could be attached to an ordinary plant. Bose discovered that ordinary plants respond to stimulus through distinctive contractions, driving his future investigations into plant response by methods of measurement and registration. From this period onwards he developed many apparatuses to plot mechanical and electrical responses of plants to stimulus. “The Optical-Pulse Recorder”, “The High Magnification

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<sup>129</sup> Bose’s investigations into metal’s molecular structure response to electric radiation led him to the question of “obtaining photography without the action of light”. In 1901, he enclosed a section of a stem in a light-tight box with a photographic plate, activating the assembled parts under the action of an electromagnetic field. Through this experiment he succeeded in producing a clear impression of the leaf structure on the photographic plate without the intervention of light. This occurred before 1939, when the Kirlian photo was developed by Semyon and Valentina Kirlian.

Crescograph” or “Resonant Recorder”, along with with galvanometric evaluation allowed him to achieve precise plots of very short time intervals, hence, enabling him to see beyond the lines of prevailing theories in plant physiology of this time (see figs. 67, 68, 69).



**Figure 67:** The “Optical-Pulse Recorder”. Source: (Geddes 1920; Bose 1926).

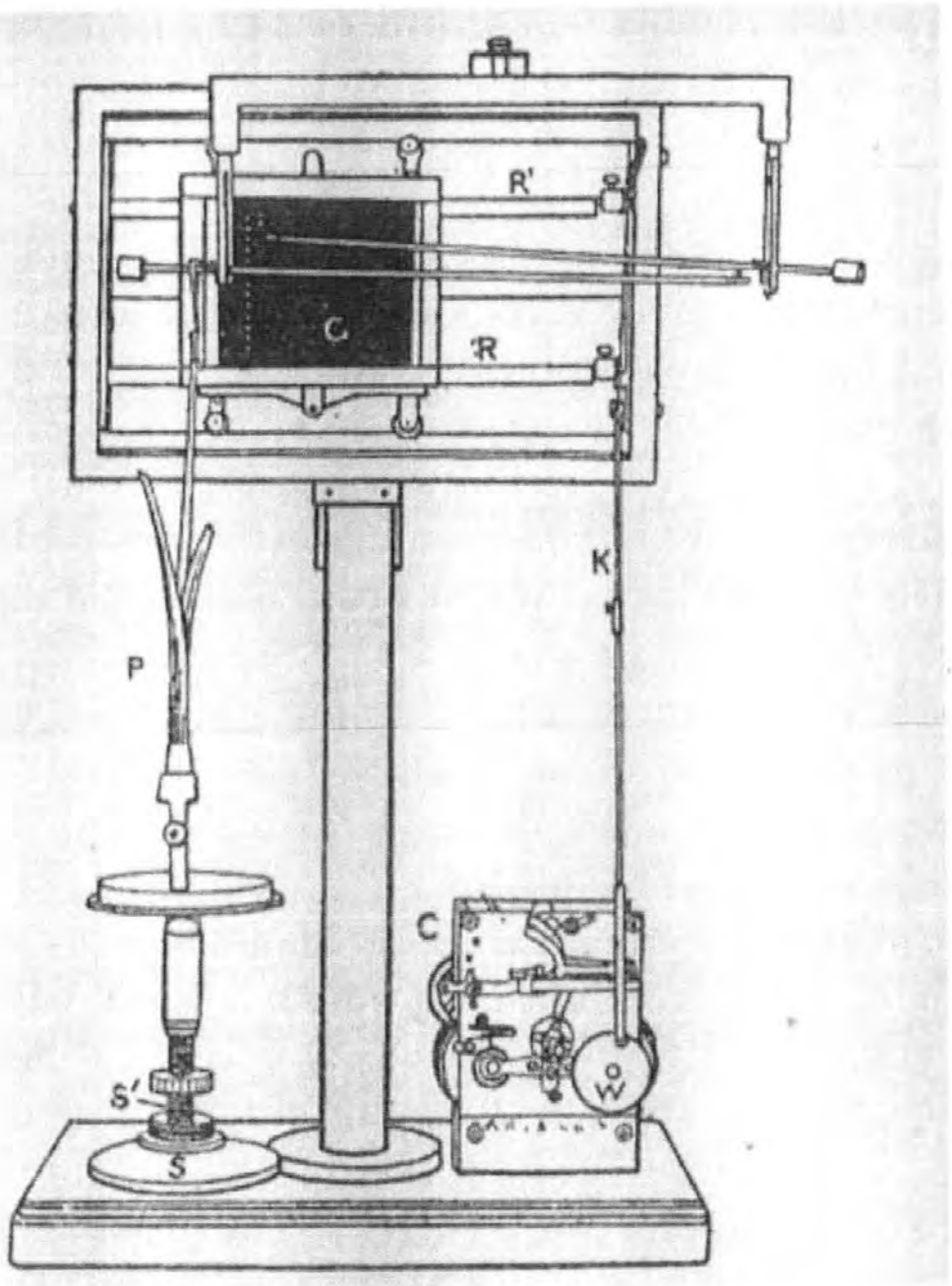
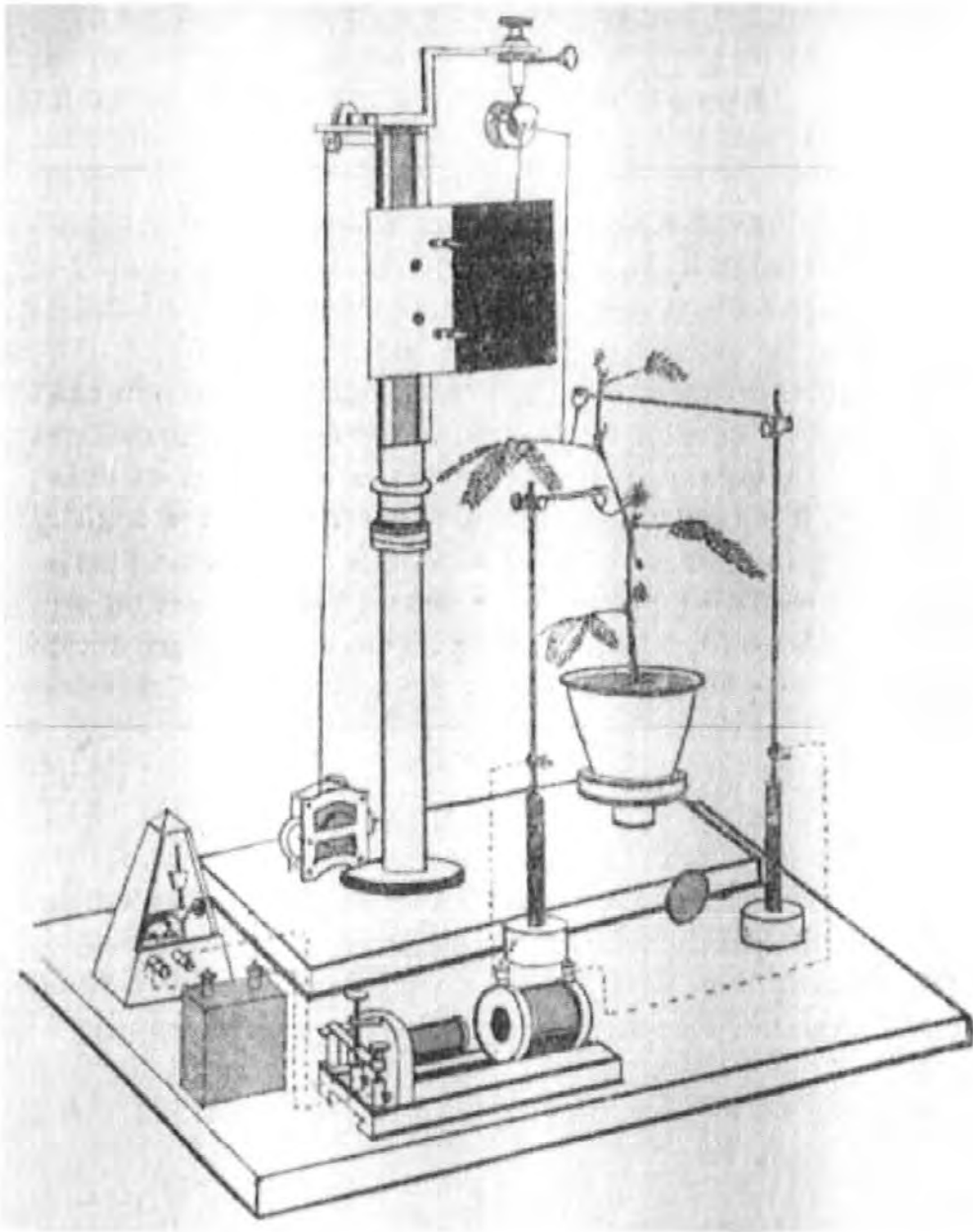


Figure 68: The "Magnification Crescograph". Source: (Geddes 1920; Bose 1926).



**Figure 69:** The “Resonant Recorder”. Source: (Geddes 1920; Bose 1926).

Bose concluded that some sort of nervous mechanism, based in protoplasmic changes that are similar to occurrences in animals, was present in plants<sup>130</sup>. This claim opposed the prevailing view that the transmission of excitation was merely due to the movement of water in the plant. After his death in 1937, some of his outstanding theories in

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<sup>130</sup> A full account of Bose’s theories and experiments on this subject is found in his book *The Nervous Mechanism of Plants* (Bose 1926).

plant cell became obscure; however, nowadays they are seemingly being re-evaluated by science.

He was the first to recognize the ubiquitous importance of electrical signalling between plant cells in co-ordinating responses to the environment. He may have been the first to discover electrical 'pulsations' or oscillations in electric potentials and he proved that these were coupled with rhythmic movements in the telegraph plant *Desmodium*. Bose theorized that regular wave-like 'pulsations' in cell electric potential and turgor pressure were an endogenous form of cell signalling. He put forth a radical theory for the mechanism of the ascent of sap, based on electromechanical activities of living cells. (Shepherd 1999)

### 6.1.3 Plants as sentient beings

Even if they possess some sort of nervous system, as claimed by J. C. Bose, plants do not appear to present most of the physiological attributes of perception, the so-called five senses, as found in humans. This belief has been challenged in much scientific and non-scientific literature (Bose 1926; Backster 1968; Bolton 1974; Tompkins and Bird 1973; Coghlan 1998; Britton and Smith 1998; Arantes 1999; Retallack 1973; Abramson et al. 2002; Backster 2003; Karban and Shiojiri 2009) and prominently by the interventions of Cleve Backster in the 1960s. To designate the phenomenon by which plants appear to demonstrate an attunement to the environment and other living beings, Backster used the term "primary perception". The "Backster Case", as it became known in the scientific community, is considered by many scientists as a pseudoscience. In the field of arts, however, it has inspired many relevant experiments and initiatives<sup>131</sup>. The following paragraphs will discuss Backster's experiments and the field opened by his research.

During the 1960s, Cleve Backster, America's foremost lie-detector examiner, became famous after an experiment that accidentally observed biocommunication with

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<sup>131</sup> Addressing directly the work of Backster and the phenomenon of primary perception, the curator Aaron Gach organised the exhibition *Psychobotany* in 2007.

plants. Backster used, speculatively, lie-detector equipment to measure how long it would take for water poured into the plant-pot to reach the top leaves of his office plant, a *Dracaena Cane*. He was surprised when the instrument's recording showed traces resembling human response to emotional stimulation. As a consequence of these results Backster started thinking about how he could threaten the plant's well-being, influenced by his expertise as a trained lie-detector examiner.

(...) the imagery entered my mind of burning the leaf I was testing. I didn't verbalize, I didn't touch the plant, I didn't touch the equipment. The only new thing that could have been a stimulus for the plant was the mental image. Yet the plant went wild. The pen jumped right off the top of the chart. (...) From that split-second my consciousness hasn't been the same. My whole thought process, my whole priority system, has been devoted to looking into this. (Backster 1997)

From the 2<sup>nd</sup> of February 1966 onwards Backster adjusted his routine to incorporate research into what he soon began to call primary perception. What followed was the transformation of his office into a modern scientific laboratory where he carried out a succession of systematic experiments into plant perception, extending his research to the level of cellular communication. A full account of this research can be found in his book *Primary Perception* (Backster 2003).

The scientific evaluation of Backster's work in bio-communication lies within the repeatability of his experiments. Some of the attempts in replicating his results have failed. Some of these points from the "Backster Case" shall now be taken into consideration.

Backster's research did not begin with a concern as to whether or not plants and other living organisms are attuned to one another, or even the way they do such things. It shall be remembered that Backster "had never conceived of becoming involved with 'bio-communication', as the cutting edge of consciousness research" (Backster, p. 11); he was put into this field by chance, and his consciousness has changed to accept his role from the



moment he believe he touched on something that was unfamiliar, and developed his own method of investigation.

The main criticism of Backster's work lies with repeatability. In his defence he claims:

"The events I've seen must be spontaneous. If you've thought them out in advance, you've already changed them. It all boils down to a very simple thing: repeatability and spontaneity do not go together, (...) There have been a few attempts by scientists to replicate my work with the brine shrimp [when he registered plant reaction to live shrimps fallen down in a boiling water in an automatized experiment], but these have all been methodologically inadequate. When they learned that they had to automate the experiment, they merely went to the other side of a wall, then, used closed-circuit television to watch what's going on. Clearly, they weren't removing their consciousness from the experiment. (Backster 1997)

The work of Backster fits well into the issues of consciousness studies. It has resonance with the work of Sheldrake and the concept of morphic resonance (Sheldrake 1999; Sheldrake and Pam 2000) and Pribram's holomonic model, which claims that were human beings able to see the world without the focus (and restrictions) of our sensory apparatus, the world would be felt as resulting from an holographic experience. (Pribram 1969; Swanson 2005) However, perhaps most importantly, there is a particular quality shared with the roots of cell communication research, as found in Alexander Gurwistch's experiments with onion roots. This interconnected field of resonances is what gives Backster's notion of "primary perception" value as a possible model to be explored in the context outlined by this research.

#### **6.1.4 General concept**

The project "Leaves System" consists of four artworks in which the relationship between plants and humans are explored poetically. "Happiness" and "Ephemera" are videoart. They resonate with past exploratory experiments by the author in the field of

video art and screen-based media. These works shall be seen as a mode of enquiry into the realm of plants and helped to engross the author into this subject. Both works deal with the movement of plants enhanced by time-lapse video techniques.

“Equilibrium” and “Breathing” are hyperorganisms that are constituted from a technical object hybridized with a natural system, in these cases a plant. To a certain extent it could be said that the plant is a “natural” element in the body of the technical system. Therefore, these projects explore hybrid modes of coherence through the dialogue between natural and artificial forces. “Breathing” invests in the examination of plants as sentient beings for exploring processes of bio-communication in arts. The plant responds to the observer’s breathing attributes, providing a new phenomenological and conceptual dimension to the issue of interaction and contributes to heightening the experience of the artwork to the affective layer.

## **6.2 Works**

### **6.2.1 “Happiness”**

#### **Description**

“Happiness” (see fig. 70) is an experimental video in which a performer interacts with animated drawings of imaginary beings and plants. “Happiness” emerged from an envisioned interconnection of plants and humans. The work consists of animations and time-lapse movies of plants projected onto the performer’s body. The video is experimental and kept in low resolution as an attempt to increase the level of intimacy between the

images and the audience. “Happiness” was invited for the exhibition “The intertwining line. Drawing as subversive art” at Cornerhouse, Manchester, United Kingdom, in 2008.



Figure 70: “Happiness” © 2007, Guto Nóbrega.

### **Production details**

Performance: Zosia Sozanska.

Music: Sofie Loizou - music - Lost (featuring Natalia Grosiak).

Time-lapse movie of plants: Roger P. Hangarter.

### **6.2.2 “Ephemera”**

#### **Description**

The projection of time-lapse movies of plants on the body in “Happiness” lead to a second video called “Ephemera” (see fig.71). “Ephemera” expands the investigation about plants into the context of art, technology and humans. In the arts, as well as in nature, light always has been a fundamental component. In this project the element of light was taken as the metaphor, as well as the physical path that merges human beings and nature in a single landscape. In a world mediated by technology, art endures as one of the key actions for reconciliation between human intuition and the vital energies concealed in nature. Plants are alive and in motion, but they exist in a mode of being that means many of their behaviours escape human perception. “Ephemera” builds its poetic upon these different temporalities to create a space in between. Its metaphor aims to bring visibility to such an interstice in which new forms of being may occur. More than transforming the human skin in a sort of organic screen, “Ephemera” is rather using light as a medium for amalgamating beings of different nature but which might share an inner connection: organic life.



Figure 71: “Ephemera” © 2008, Guto Nóbrega.

### Production details

Sound designer: Eduardo Coutinho.

Time-lapse movie of plants: Roger P. Hangarter.

Participants: Aga, Bruna Alves, Jenny Lali Krotozinsky, Leandro Costalonga, Maria Campbell, Maria Aline, Patrícia Freire, Sana Murrani, Thiers, Theo.

### 6.2.3 “Equilibrium”

#### Description

“Equilibrium” (see fig. 72) is described in the Part II of this thesis, in the subsection titled “Equilibrium”.

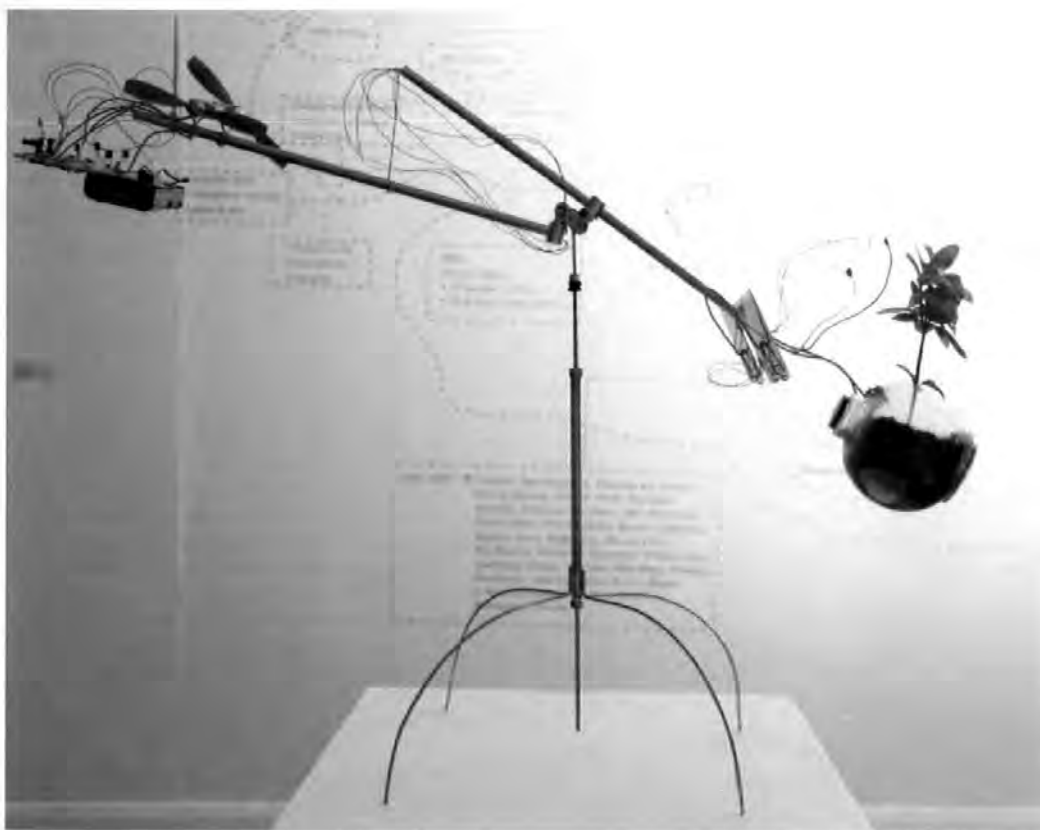


Figure 72: “Equilibrium” © 2008, Guto Nóbrega.

## **“Equilibrium” architecture**

“Equilibrium” is based on an electronic circuit that gives the artificial system its “photovore” qualities. “Photovore” is a chief characteristic of certain BEAM robots<sup>132</sup> (Tilden 2000; Hrynkiw and Tilden 2002), recognised by their behaviour of searching for light. The artificial mechanism employed in “Equilibrium” behaves following an inversion of that principle. It avoids light (the circuit of this robot is presented in the Appendix 2). As the artificial system and the plant are set in balance, yet in geometrical opposition (see fig.71), in avoiding the light source the structure rotates on its axis and exposes the plant to the light. The conversation with the observer occurs according to the way he/she interposes him/herself in between the light source and the hyperorganism.

### **6.2.4 “Breathing”**

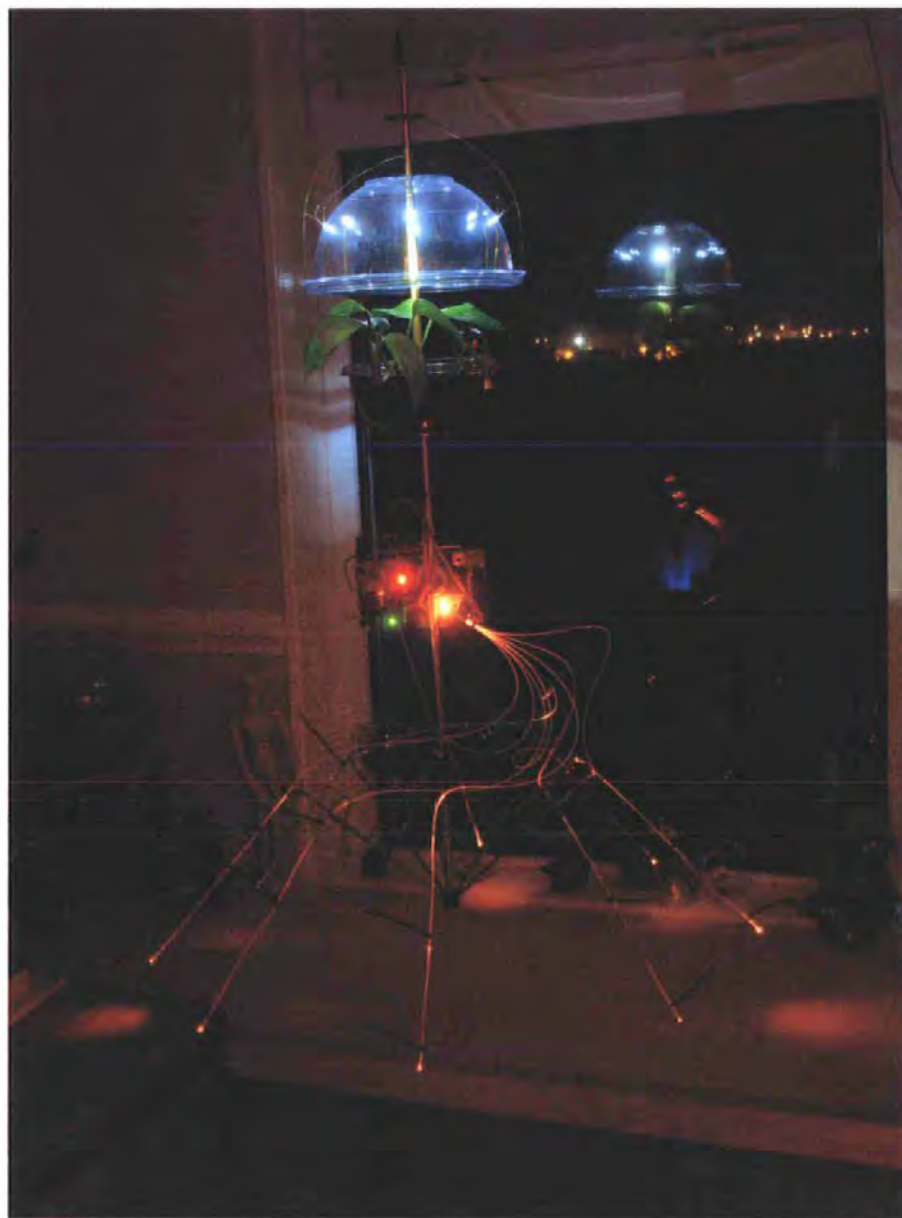
#### **Description**

“Breathing” (see fig.73) is a work of art based on a hybrid creature made of a living organism and an artificial system. This hyperorganism responds to its environment through movement, light and the noise of its mechanical parts. Breathing is the best way to interact with the creature. This work is the result of an investigation into plants as sensitive agents for the creation of art. The intention was to explore new forms of artistic experience through the dialogue of natural and artificial processes. Breathing is a pre-requisite for life, and is the path that links the observer to the creature. “Breathing” is a small step towards new art forms in which subtle processes of organic and non-organic life may reveal invisible patterns that interconnect us. It is a work of art driven by biological impulse. Its

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<sup>132</sup> BEAM robotics is an acronym for Biology, Electronics, Aesthetics, and Mechanics.

beauty is neither found isolated in the plant nor in the robotic system itself. It emerges at the very moment in which the observer approaches the creature and their energies are exchanged through the whole system. It is in that moment of joy and fascination, in which we find ourselves in a very strange dialogue, that a life metaphor is created. Breathing is the celebration of that moment.



**Figure 73:** “Breathing” © 2008, Guto Nóbrega.

## **Context**

In the 1960s the Brazilian artist Lygia Clark created a series of geometric structures made from metal plates of different sizes and formats joined together by hinges. These modular creatures needed to be manipulated by the viewer as a condition to unfold its numerous formal possibilities. This series was called *Bichos* (Animal, Beasts).

When asked about how many movements *Bichos* could do, Clark answered categorically: “I don’t know, you don’t know, but he knows...” (Clark 1980, p. 17)

From the past 48 years we have seen in art a move from the creation of objects to hyperorganisms. New creatures arising from the intersection of art, science and technology have confirmed Lygia’s suspicion, answering autonomously to the observer’s enquiry. Maybe it is now time to shift the question to understand the nature of these new organisms. The correct question should be, not about how many movements the creature can make or how many forms it can take, but in fact: What are these new creatures, made of organic and artificial parts, trying to say?

“Breathing” resonates with Clark’s prediction that the “relationship between artwork and spectator – in the past virtual – becomes affective” (*Ibid.*).

### **“Breathing” architecture**

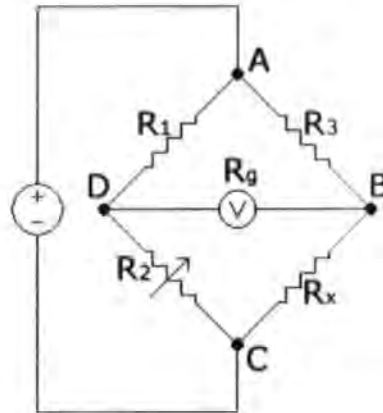
“Breathing” is based on monitoring the electro-conductivity of the plant’s leaves and uses the data as variables to feed an interactive system. The driven idea of this project was the use of plants as biological sensors. In order to do this, firstly it was adapted an electronic circuit designed by Lucas George Lawrence<sup>133</sup>, published at Popular Electronics

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<sup>133</sup> Lucas George Lawrence was an electronics specialist employed as an instrumentation engineer for a Los Angeles space-science corporation. He was involved in a project to develop jam-proof missile components and came across the idea that using plant tissue as transducers would give the best results. He thought “that



in June 1971 (see Appendix 2). The core of the circuit is a Wheatstone bridge (see fig.74), a combination of four resistors as shown in the figure below.



**Figure 74:** Wheatstone bridge. Source: Wikipedia.

In such an arrangement, if we keep the balance of two legs of a bridge circuit, meaning that the ratio of the two resistances in the leg ( $R_2 / R_1$ ) is equal to the ratio of the two resistances in the leg ( $R_x / R_3$ ), then, the voltage between the two midpoints D and B will be zero<sup>134</sup>. However, considering  $R_x$  is a variable resistance it turns out that variations in the value of  $R_x$  will correspond to changes in the voltage between the points D and B. It is exactly this that is of interest in this system.

Replacing  $R_x$  with the plant leaf (see fig.75) enables the measurement of small variations in the leaf's electrical conductance. The plant acts as a biological variable resistor. So, small changes in the leaf's conductance will disrupt the balance of the bridge

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living plant tissues or leaves were capable of simultaneously sensing temperature change, gravitational variation, electromagnetic fields, and a host of other environmental effects — an ability no known mechanical sensor possessed” (Theroux 1997). It is worth mentioning that his investigations introduced Lawrence to the work in cells communication developed by Alexander Gurwitsch (*Cf.* section Biophoton historical background). Based on Gurwitsch's work and with the understanding of Cleve Backster's experiments with plants and polygraphs, Lawrence started developing various psycho-galvanic analyzers to detect responses in plants.

<sup>134</sup> *Cf.* Wheatstone Bridge (Bridge 2006).

and will be readily detected by the appearance of an equivalent voltage between the points D and B.

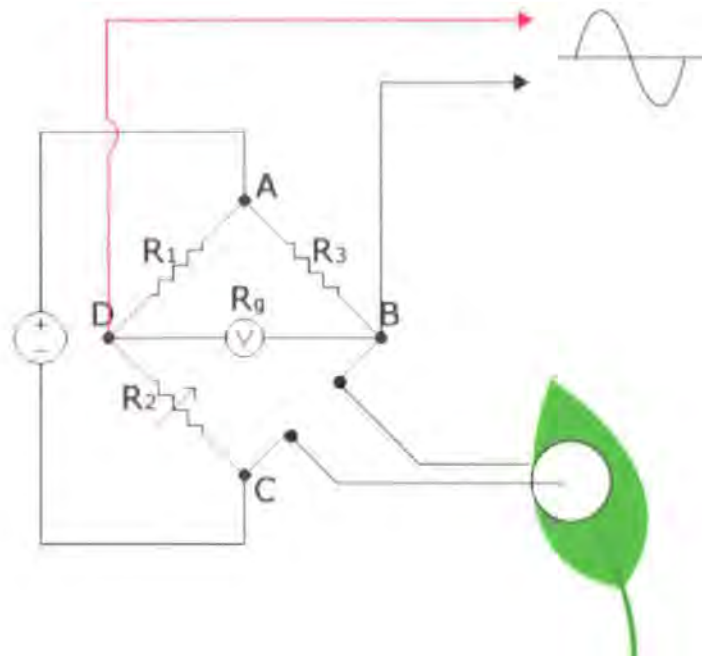


Figure 75: Wheatstone bridge with a plant as sensor. © 2009, Guto Nóbrega.

Since the variation of voltage at D and B is in the order of millivolts, the second stage of the Lawrence's circuit uses a general purpose operational amplifier to magnify this small voltage by a thousand times. This allows for the reading of an analogical signal as output, ranging between 0 and 5 volts. This signal is applied to Arduino<sup>135</sup>, a microcontroller, in order to be translated in sound, movement and lights.

<sup>135</sup> Arduino is "an open-source physical computing platform based on a simple i/o (input/output) board, and a development environment for writing Arduino software" (Arduino 2006).

## 7 Conclusion

Throughout the present study four domains of knowledge – art, technology, science and nature – have been reviewed, in accordance to the central concepts of resonance, coherence and integrative field. These concepts were articulated in order to provide a new principle for aesthetics for the purpose of overcoming the predominant mechanistic thought in the confluence of the domains of art and technology. The goal of this study was to shift attention to concepts such as immateriality, interconnectivity and immersion, going beyond the technocentric discourse and reframing these issues as inherent attributes of the aesthetic experience.

In order to tackle this, it was necessary to develop a new theoretical framework and new specific concepts such as “iField” and “hyperorganism”. Also some major philosophical moves were necessary. The concept of “apparatus” opened the thesis’ analysis and provided a framework to understand technological issues beyond the typical discourse of digital new media. Vilém Flusser pointed to the importance of experimentalism as a strategy of freedom and emancipation in the dialogues developed with technology. This initial discussion allowed the argument to open the apparatuses “black-box” (Flusser 1984) and to expand the analysis of the “operator-apparatus” into a more dynamic complex, the artist-artwork-observer triad.

Gilbert Simondon provided the theoretical framework to analyse the contemporary invention of technological objects in the context of art. Simondon’s theory was fundamental in situating the locus of invention as an intervention in the process of concretization of technological beings. Nature and culture could be said to be interlinked by coherent processes of resonance.

The thesis re-examined the concept of form, supported by a *Gestalt* analysis as provided by Rudolf Arnheim, so that the notion of form, process and behaviour could be reintegrated. This move was fundamental to understanding the space-time of aesthetic experiences as a diagram of forces. It also establishes the conceptual bridge between aesthetics and biology through the notion of an integrative field.

The principal intention of this thesis has been to establish an integrative model of aesthetics. This intervention was thought to be necessary because it is only through the process of integrating actions, ideas, discourses and practices into coherent wholes that patterns can be created, revealing the manner in which things interconnect. Patterns are necessary in so far as they reveal what things are about. Where things in the world exist in isolation they lack meaning, a situation that requires addressing.

Burnham observed that “[t]he specific function of modern didactic art has been to show that art does not reside in material entities, but in relations between people and between people and the components of their environment” (Burnham 1968b). A problem becomes apparent, however, as this idea was never fully developed or put into practice, since for many artists the conceptual shift from things to relations, from objects to process, merely led to improvements in ways of making things work. This thesis has argued that we should investigate the nature of behaviour, and seek to understand the significance of patterns of process. The shift from object to process means more than a new trend in arts. It is the initial step for more ambitious changes.

The aim of an integrative theory is not to see all parts together as stable totalities. That would take us to another form of individualism, just elevated to the extreme. The extremities should be avoided, as they lead to dualistic dichotomies such as reductionism/holism. This is one of the main values in introducing Simondon’s philosophy into this context. Simondon does not proclaim individualism, but individuation. The

individual, in his understanding, is not an entity, but an ongoing process (Simondon [1958] 1989; 1989).

To capture the nature of process, this thesis has outlined a focus on the interstitial space of things, since by performing this practice the patterns and forces of their connections may be revealed. A field picture of reality may be the only way to grasp the puzzling notions of nonlocality, nonseparability and interconnectedness, that contemporary science proposes, and that intuitively has always been part of human knowledge.

The study has led the thesis into arguing for the necessity of pointing a way through art to a necessary shift of consciousness, calling for realignments of the arts as a whole. This shift would offer the opportunity to read the intrinsic patterns of nature, rather than trying to reorganise its elements in our own way. Without such a shift in consciousness, art will continue to simply seek answers to means but fail to find any meaning.

This thesis' contribution to new knowledge, necessary to initiate such a shift, is the organisation of aesthetic principles built upon the notions of resonance, coherence and field models, rooted in an integrative view of living organisms and supported by the theory of biophotons.

According to biophotonic research, we could say that the way to a new consciousness is through the understanding of coherence, seeing coherence as the key to integration, concretization, and individuation. This thesis has attempted to show that art has always taught us this. The methodology adopted in the art practice that informs this thesis reflects such an apprenticeship.

What has been presented here provides a theoretical model of practice that calls for further development, pointing towards new fields of research into nature. The potential of coherence in natural processes provides an open platform for the invention and communication of new aesthetic forms. The theoretical model outlined by this thesis can be

seen as a new organic form that needs to evolve and multiply, calling for further interrogation and discussion. It is this path that future research will hope to take.

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## 9 Appendices

### 9.1 Appendix 1 – Author’s publication, conference, and seminar list

In this appendix, a list of publications, conferences and seminars attended and coordinated by the author is provided. These include a list of the Planetary Collegium’s ten-day composition sections in which research updates were presented to fellow students and supervisors, whilst one-to-one tutorials were held each time with the main supervisory board comprised of Professor Roy Ascott, Mr. Mike Phillips and Professor. Michael Punt.

#### 9.1.1 Publication list

- NÓBREGA, C. (2005) Luz & Letra. Review of Eduardos Kac's book Luz & Letra. IN FERREIR G. & VENÂNCIO, P. (Eds.) *Arte & Ensaio*. Rio de Janeiro, A & E.
- NÓBREGA, C. (2006) Biophoton – The language of the cells. What can living systems tell us about interaction? *Technoetic Arts*, vol.4, nº3, pp. 193-201.
- NÓBREGA, C. (2006) Biófoton - a linguagem das células. O que os sistemas vivos podem nos dizer a respeito de interação? *F.A.q. > Questions about Art, Consciousness & Technology* Brazil, Abstract available at: <http://www.faq.art.br/br.html>. Accessed on: 11/12/2006.
- NÓBREGA, C. (2006) Arte como um campo de interações. *Revista Concinnitas*.
- NÓBREGA, C. (2007) Leaves System: Art Experiment in Plant Communication and Primary Perception. IN PHD, P. A. (Ed). *REVIEWING THE FUTURE: Vision, Innovation, Emergence. Abstracts of the 2007 Planetary Collegium Summit*. Quebec - Canada, Planetary Collegium.
- NÓBREGA, C. (2008) Interconnecting minds. Playing art. *Exhibition Catalogue, Conference Proceedings. Homo Ludens Ludens*. LABoral, Gijon, LABoral Centro de Arte y Creación Industrial.
- NÓBREGA, C. (2008) Art as a field phenomenon. *Conference proceedings of the International Symposium on Electronic Art 2008*. Singapore, ISEA.
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- NÓBREGA, C. (2008) Art as a field phenomenon. *Toward a Science of Consciousness 2008*. Tucson ARIZONA - Tucson Convention Center - Accepted unpublished work.
- NÓBREGA, C. (2008) Towards a Pseudoart. Science, Pseudoscience and Intuition. *SLSA Conference: Figurations of Knowledge*. Berlin - Accepted unpublished work.
- NÓBREGA, C. (2008) Art as an interactive field. Subtle liaisons. IN ASCOTT, R., BAST, G. & FIEL, W. (Eds.) *New realities: Being syncretic*. Wien/New York, Springer.

### **9.1.2 Conferences and lectures**

- 2009 - BEYOND DARWIN: The co-evolutionary path of art, technology and consciousness – University of Plymouth - Roland Levinsky Building
- 2009 - BEYOND DARWIN: The co-evolutionary path of art, technology and consciousness – Sala Parpalló – València - Spain
- 2008 - The Planetary Collegium's IXth International Research Conference: Consciousness Reframed – Vienna - 2008 - Theme: New Realities: Being Syncretic. A transdisciplinary inquiry into art, science, technology and society. Partner and Host: University of Applied Arts Vienna
- 2008 - HOMO LUDENS LUDENS - LABoral Centro de Arte y Creación Industrial <http://www.laboralcentrodearte.org/es/402-concepto>
- 2007 - The First Summit Meeting of the Planetary Collegium - Montréal, Canada – <http://summit.planetary-collegium.net/>
- 2006 - ?F.A.q. > Questions about Art, Consciousness & Technology - Brazil,
- 2006 - Consciousness Reframed 8: art & consciousness in the post biological era Plymouth - UK - 21 - 23 July
- 2006 - Digital Arts Symposium - University of Arizona College of Fine Arts – 2006
- 2005 - Apollo 38 – I-DAT space programme – 2006
- 2005 - Graphic Design and Digital Arts students, University of East London – i-Dat

### **9.1.3 Composite sessions attended**

- 2006 - Arizona, Plymouth and Brazil
- 2007 - Canada, Plymouth and Gijon
- 2008 - Vienna
- 2009 - València

### **9.1.4 Seminars attended**

- Transtechnology Research Seminars – 2005 to 2009.
- Computer Music Research Seminar- 2006
- Organiser and monitor of the Ph.D. Studies Group series – i-Dat -2008

### **9.1.5 Workshops attended**

- [ARDUINO MEETS PROCESSING WORKSHOP] - Plymouth Campus - 24 – 26 May 2006, i-DAT, University of Plymouth
- Research Training Workshop on the subject of “Originality” - Plymouth Campus
- OpenMute – Floss – Open source culture - Plymouth Campus

### **9.1.6 Participation and organisation of events**

- Mutate – Barbican Theatre – Plymouth

### **9.1.7 Exhibitions**

- 2008 The Intertwining Line. Drawing As Subversive Art – Cornerhouse – Manchester - UK
- 2008 Estrategia - Artists from Brazil – Plymouth Art Centre – Plymouth - UK
- 2006 Mutate - Barbican Theatre – UK
- 2005 Prog-me – <http://www.progme.org>

## 9.2 Appendix 2 - Technical details of the practice works “Equilibrium” and “Breathing”

### 9.2.1 “Equilibrium” electronic circuit

The artificial structure of “Equilibrium” is based on the light seeker BEAM robot “microbug” (see fig. 76), which had its functions modified to behave avoiding light. It was done by altering its circuitry according to the scheme bellow (see fig. 77). Also the original circuit was adapted to receive power from two solar cells posited side-by-side with the plant, so that when the plant reaches the light the small robot can have its battery recharged.

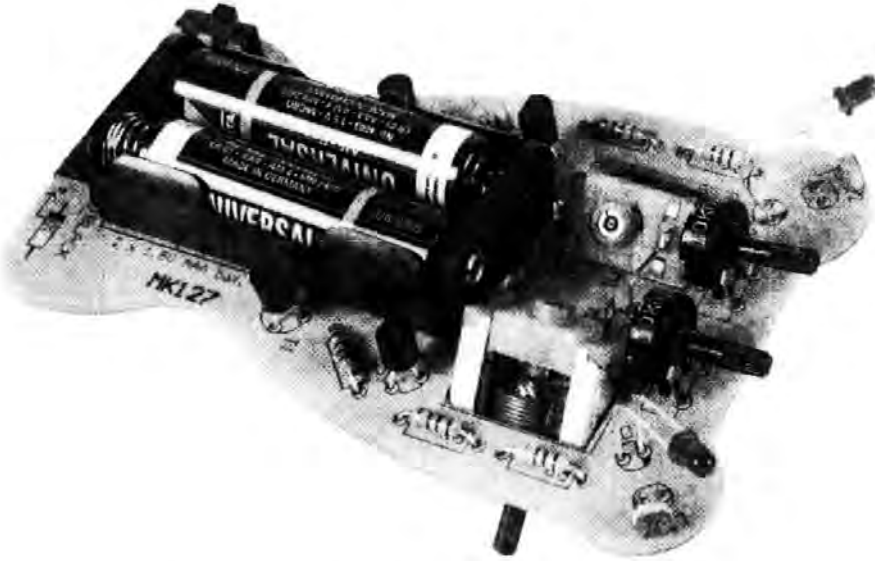


Figure 76: BEAM “Microbug”. © 2008, Guto Nóbrega.

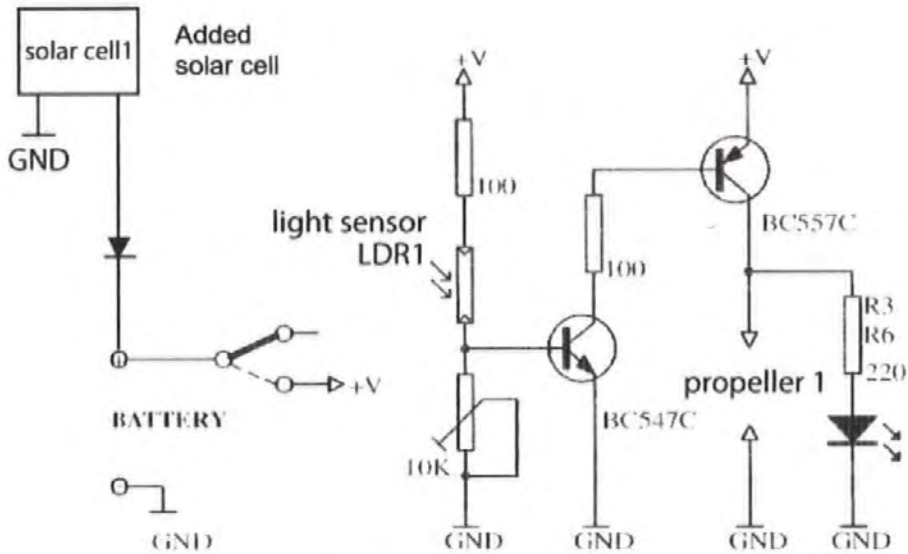


Figure 77: "Equilibrium" uses two circuits of this kind, one for each propeller. In the final circuit the position of the LDR was swapped with of the 10K pot, so the "avoiding light" was achieved. © 2008, Guto Nóbrega.

### 9.2.2 Original circuit designed by Lucas George Lawrence

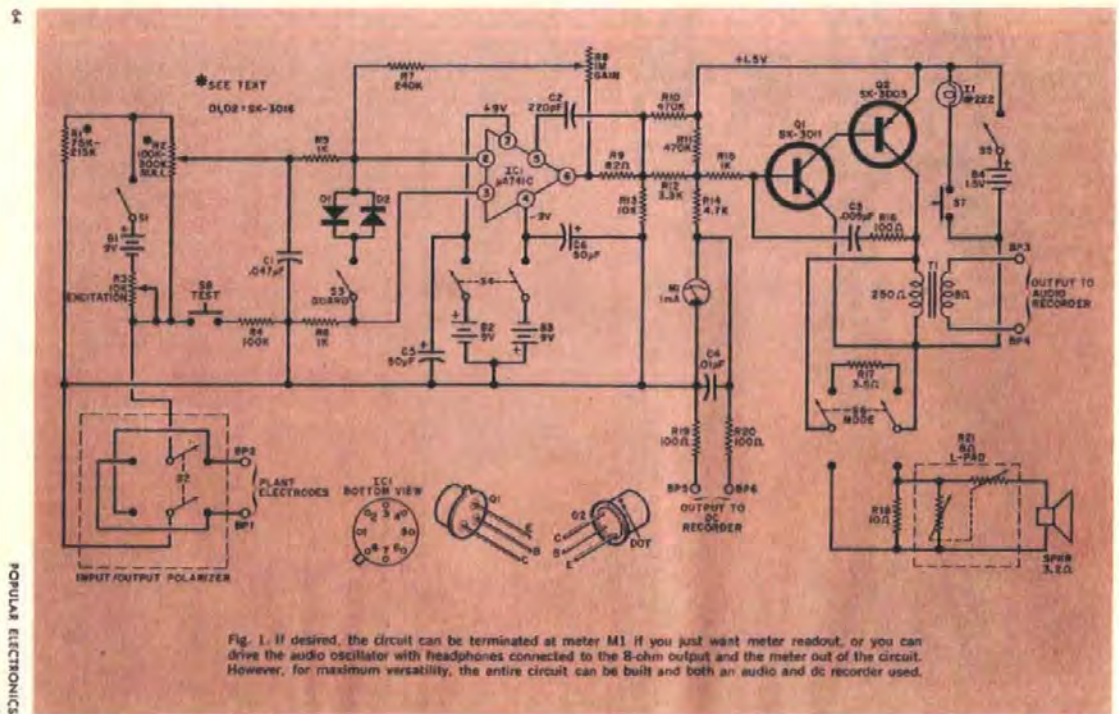


Fig. 1. If desired, the circuit can be terminated at meter M1 if you just want meter readout, or you can drive the audio oscillator with headphones connected to the 8-ohm output and the meter out of the circuit. However, for maximum versatility, the entire circuit can be built and both an audio and dc recorder used.

Figure 78: Lucas George Lawrence's circuit for "experiments in electroculture"(Lawrence 1971). Source: (Lawrence 1971).

### 9.2.3 Simplified electronic circuit utilized on this project and technical commentary.

This circuit (see fig. 79 ) is the core of “Breathing” as it interfaces with the plant’s leaf. The system calibrating process to achieve satisfactory demands a long term empirical tests of positioning the sensors and controlling the amount of current that goes through the leaf. What became truly important to a successful reading of the electrophysiological impulses of the plant was the use of a conductive gel (that unfortunately turned out to be highly abrasive for the plant’s leaves) or a very small electrode of the kind used in electrocardio monitoring systems. They are flexible and already highly conductive. The plant used on this system, a Jibóia (*Epipremnum pinnatum*), was very responsive to the observer act of breathing, but it was necessary a long period of adaptation to the electrodes and the new milieu defined by the hybridization of natural and artificial components.

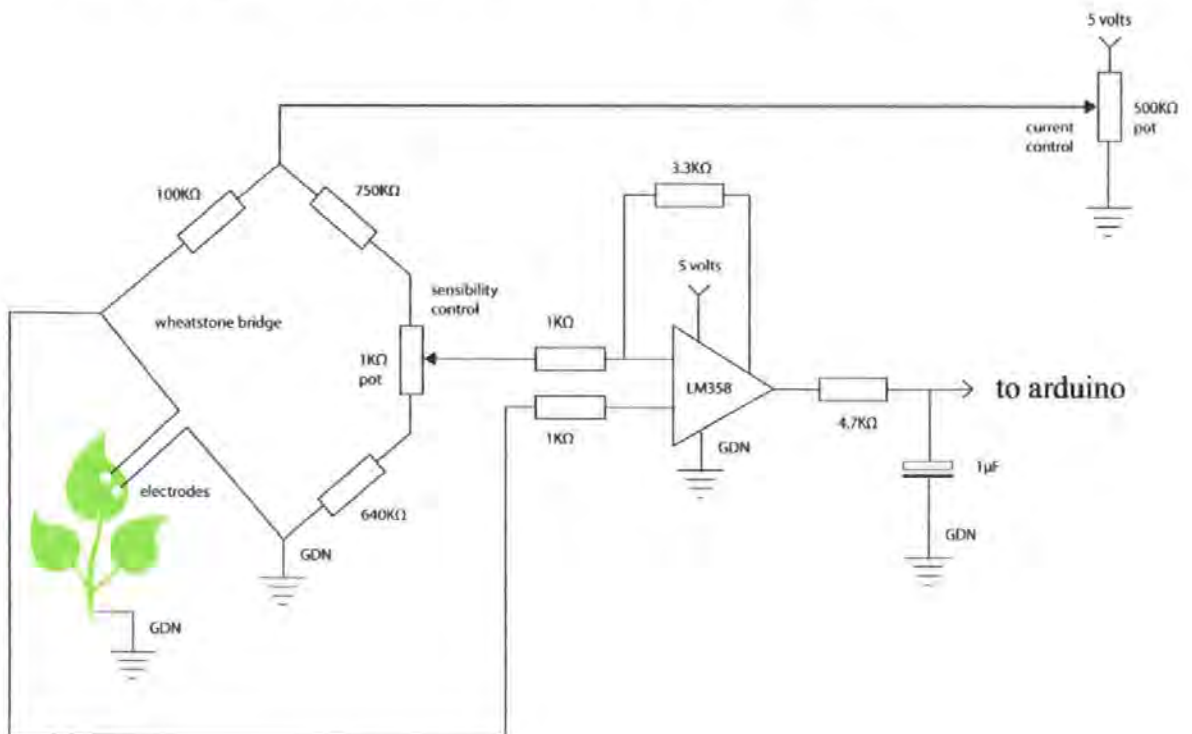


Figure 79: Breathing electronic circuit. © 2008, Guto Nóbrega.

## 9.2.4 Arduino code

The arduino code is based on tutorials codes available on the arduino website (such as blinking LEDs and the control of servo mechanisms). This code was adapted by the author in order fulfil the needs of the hyperorganism in this context. The programming stage of the project received collaboration and support from Eduardo Coutinho and Dr. Guido Bugmann, head of the Centre for Robotics and Intelligent Systems - School of Computing, Communications and Electronics - University of Plymouth.

The following code reads the outputs from the Wheatstone Bridge circuit and processes the values to control light and the servo mechanism that actuates the mechanical legs.

### Code:

```
//Smoothing
#define NUMREADINGS 20

int readings[NUMREADINGS]; // the readings from the analog input
int index = 0; // the index of the current reading
int total = 0; // the running total
int average = 0; // the average

//RGB - Variable declaration

// OUTPUT: Use digital pins 9-11, the Pulse-width Modulation (PWM) pins
int redPin = 9; // Red LED, connected to digital pin 9
int grnPin = 10; // Green LED, connected to digital pin 10
int bluPin = 11; // Blue LED, connected to digital pin 11

// Program variables
int redVal = 0; // Variables to store the values to send to the pins
int grnVal = 0;
int bluVal = 0;
int potVal = 0;

// Leds sequence - Variable declaration
int pinArray [] = {
  0,1,2,3,4,5,6,7}; // Array where I declare the pins connected to the LEDs
int controlLed = 8; //light up the Led on the digital output 13
int waitNextLed = 0; // Time before I light up the next LED
int tailLength = 3; // Number of LEDs that stay lit before I start turning them off, thus the tail
int lineSize = 8; // Number of LEDs connected (which also is the size of the pinArray)
int lastLedPulse = 0;
int ledsDir = 1; // counts the leds in one direction
int ledsON = 0; //shows the status of the current led
int elapsedTimeLed = 0;

//servo variables
int servoPin = 13; // Control pin for servo motor
int minPulse = 500; // Minimum servo position (varies according to the server)
int maxPulse = 1600; // Maximum servo position (varies according to the server)
int pulse = 0; // Amount to pulse the servo
```



```

int elapsedTimeServo = 0; //

long lastPulse = 0; // the time in milliseconds of the last pulse
int refreshTime = 20; // the time needed in between pulses in t

int analogValue = 0; // the value returned from the analog sensor
int analogPin = 1; // the analog pin that the sensor's on. It sets up the pin

void setup() // this stage runs only once and goes for the loops
{
  //smoothing
  for (int i = 0; i < NUMREADINGS; i++)
    readings[i] = 0; // initialize all the readings to 0

  pinMode(servoPin, OUTPUT); //

  //Servo
  pulse = minPulse; // Set the motor position value to the minimum
  //Serial.begin(9600); // in case I need to use the serial port I need to activate this line

  //LEDS - this function swaps the led in sequence
  int i; // declare the variable
  pinMode (controlLed, OUTPUT); // Set servoPin (13) as an output (I don't know why it is here)

  for (i=0; i< lineSize; i++) //it adds one led in sequence)
  {
    pinMode(pinArray[i], OUTPUT); // It sets the pin in sequence as an output
  }

  digitalWrite(pinArray[0],HIGH); // It turn the 0 pin HIGH (first led)
  ledsON = 1; //
}

void loop() // this stage goes in looping
{
  //smoothing
  total -= readings[index]; // subtract the last reading
  readings[index] = analogRead(analogPin); // read from the sensor
  total += readings[index]; // add the reading to the total
  index = (index + 1); // advance to the next index

  if (index >= NUMREADINGS) // if we're at the end of the array...
    index = 0; // ...wrap around to the beginning
  average = total / NUMREADINGS; // calculate the average
  //Serial.println(average);

  //servo loop
  waitNextLed = readAnalogVal(); // This is the way Edu showed me how to call a function written in another
  place, in this case ReadServo()
  //waitNextLed is defined by the analogValue (see below)

  elapsedTimeLed = millis()-lastLedPulse; //
  if (elapsedTimeLed >= waitNextLed) {
    ledRoutine(); // if the above is right, call the ledRoutine
    lastLedPulse = millis();
  }
  elapsedTimeServo = millis()-lastPulse;
  if (elapsedTimeServo >= refreshTime) {
    moveMotor(); //if the above is right, call the movemotor function
  }
}

```

```

    lastPulse = millis();      // save the time of the last pulse

    // Serial.println(analogRead(0)); // just in case o debugging
}

    potVal = map(average,440,540,0,1023); // declare the value for the RGB sequence. Need to put the values
    from GSR on the first bit
    RGBroutine(); // call the RGB function
}

void ledRoutine() //function for the Leds sequence
{
    if ( ledsDir==1 ){
        digitalWrite(pinArray[ledsON],HIGH); // | light up consecutively the LEDs
        ledsON = ledsON + 1;
        if (ledsON == lineSize ){
            ledsDir = -1;
        }
    }
    else{
        digitalWrite(pinArray[lineSize-ledsON],LOW);
        ledsON = ledsON - 1;
        if (ledsON == 0 ) ledsDir = 1;
    }
}

int readAnalogVal() //function to read analog value
{
    int valueRead = 0;
    analogValue = average;      // read the analog input
    pulse = map(analogValue,440,540,minPulse,maxPulse); // send the analogValue to the servo
    valueRead = map(analogValue,350,400,10,200); // send the analogValue to the light sequence
    return valueRead;           //return the value as a valueRead
    // Serial.println(pulse);
}

void moveMotor() //function to moveMotor
{
    digitalWrite(servoPin, HIGH); // Turn the motor on
    delayMicroseconds(pulse); // Length of the pulse sets the motor position
    digitalWrite(servoPin, LOW); // Turn the motor off
}

void RGBroutine() //function to change RGB leds
{
    if (potVal < 341) // Lowest third of the potentiometer's range (0-340)
    {
        potVal = (potVal * 3) / 4; // Normalize to 0-255
        redVal = 256 - potVal; // Red from full to off
        grnVal = potVal; // Green from off to full
        bluVal = 1; // Blue off
    }
    else if (potVal < 682) // Middle third of potentiometer's range (341-681)
    {
        potVal = ( potVal-341 ) * 3 / 4; // Normalize to 0-255
        redVal = 1; // Red off
        grnVal = 256 - potVal; // Green from full to off
        bluVal = potVal; // Blue from off to full
    }
    else // Upper third of potentiometer's range (682-1023)

```

```

{
  potVal = ( (potVal-683) * 3) / 4; // Normalize to 0-255

  redVal = potVal;    // Red from off to full
  grnVal = 1;        // Green off
  bluVal = 256 - potVal; // Blue from full to off
}
analogWrite(redPin, redVal); // Write values to LED pins
analogWrite(grnPin, grnVal);
analogWrite(bluPin, bluVal);
// Serial.println(average);
/* if (DEBUG) { // If we want to read the output
  DEBUG += 1;    // Increment the DEBUG counter
  if (DEBUG > 100) // Print every hundred loops
  {
    DEBUG = 1; // Reset the counter
    // Serial output using 0004-style functions
    Serial.print("R:"); // Indicate that output is red value
    Serial.print(redVal); // Print red value
    Serial.print("\t"); // Print a tab
    Serial.print("G:"); // Repeat for grn and blu...
    Serial.print(grnVal);
    Serial.print("\t");
    Serial.print("B:");
    Serial.println(bluVal); // println, to end with a carriage return
    Serial.println(average); // send it to the computer (as ASCII digits)
  }
}*/
}

```

### 9.3 Appendix 3 - Plant based works

This is a list of works that have informed in some manner the practice methodology of this thesis. The idea of this section of the appendix is to provide a link to artists working with plants, providing a map to this field of research. The links are organised in alphabetical order by the name of the artist, the title of the work, a brief description and the respective website.

Gregory Lasserre and Anais met den Ancxt  
**Akousmaflore** (2008)  
Sensitive and interactive musical plants  
[http://www.scenocosme.com/creation\\_e.htm](http://www.scenocosme.com/creation_e.htm)

David Bowen  
**Bamboo network** (2008)  
“This system provides food (hydroponic solution) and physically arranges 7 bamboo stalks in relation to available light in a particular space. The composition of the piece is determined by the growth of the bamboo and how it and the device collectively respond to their surroundings” (Bowen)  
<http://www.dwbowen.com/index.html>

Rob Faludi, Kate Hartman, and Kati London  
**Botanicalls** (2007)  
“is a system that was developed to allow plants to place phone calls for human help”  
<http://www.botanicalls.com>

Daniel Cambil & Daniel Roberts (2007 )  
**EMLI** (a plant detector) “is used to explore the physical phenomenon of organic semiconductors” (Cambil and Roberts 2007)  
<http://www.vslvx.org/EMLI/II/>

Douglas Irving Repetto (2005)  
**Fly Away (Not Going Very Far)**  
“A Prayer Plant (*Maranta leuconeura*) in a rusty cage has its picture taken every five minutes. A raw LCD monitor plays a loop of the accumulated images, speeding up the slow folding and unfolding of the plant's leaves to a human timescale. An invitation to misunderstand” (Repetto 2005)  
<http://music.columbia.edu/~douglas/portfolio/FANGVF/>

John Lifton

**Green Music: (1976 )**

“Over four days in late June 1976, while open to the public, six large plants in the center of the glass Plant Conservatory in San Francisco’s Golden Gate Park, produced an audible, live digital music score, based on bio-electric sensing of their responses to light, temperature, movement and other physio-environmental factors (using gold needle electrodes at the base of the stem and root). This was John Lifton’s interactive “Green Music” composition and installation.” (Gach 2007)

<http://www.psychobotany.com/projects/John%20Lifton.htm>

Christian Guetzer

**Grow - Fruits of Kronos (2009)**

"Grow" is a project that deals with the plant/machine conception. A machine that is controlled by a special algorithm, changes the position of the plant relatively to a static light source". (Guetzer 2009)

<http://5voltage.com/typolight/typolight257/index.php?id=1&articles=13>

Mateusz Herczka

**Life Support Systems - Vanda Hybrid Orchids (2005)**

“The installation collects data generated by the tiny shifts in electrical current produced by the metabolic processes of vanda hybrida orchids”.(Herczka 2005)

<http://www.we-make-money-not-art.com/archives/2005/05/thinking-about.php>

Masaki Fujihata and Yuji Dougane, Japan

**Orchisoid, (2001 )**

“Orchid, interactive brain wave visual analyzer, mobile, computer, custom-made brain-like software” (Fujihata 2002)

<http://muse.jhu.edu/login?uri=/journals/leonardo/v035/35.5fujihata02.pdf>

Miya Masaoka

**Pieces for Plants (2007)**

a plant’s real-time responses to its physical environment are translated to sound.

<http://www.miyamasaka.com>

Richard Lowenberg

**Plant Music (1976)**

Plant with transducing device and video monitor with biofeedback display.

[http://greenmuseum.org/content/wif\\_detail\\_view/img\\_id-619\\_\\_prev\\_size-1\\_\\_artist\\_id-94\\_\\_work\\_id-149.html](http://greenmuseum.org/content/wif_detail_view/img_id-619__prev_size-1__artist_id-94__work_id-149.html)

Tom Zahuranec (1972)

**Plant audio synthesis interface**

Zahuranec's customed engineered system for doing (GSR/Backster Effect) plant-audio synthesis interface works beginning in.

Aaron Gach (curator)

**PSYCHOBOTANY**

“Revolutionary Breakthroughs in Human/Plant Communication

Psychobotany attempts to cultivate a cultural terrain that includes a wide array of efforts at human/plant communication. Artists, scientists, subcultures, religions, activists, and visionaries all share plots in the field of Psychobotany. Combining elements of scientific truth, spiritual beliefs, aesthetic savvy, and social expression, Psychobotany is a fertile ground where the diverse cultural roots of human/plant communication can take hold” (Gach 2007)

<http://psychobotany.com/intro.htm>

Allison Kudla

**The Search for Luminosity** (2008)

Autonomous biotechnological installation

[http://www.washington.edu/dxarts/profile\\_research.php?who=kudla&project=Eden](http://www.washington.edu/dxarts/profile_research.php?who=kudla&project=Eden)

Aaron Gach

**Vital Psigns:** (2007)

The Center for Tactical Magic's Vital Psigns is a social experiment that seeks to address individual mind power and the potential for human/plant communication.

<http://www.psychobotany.com/projects/CTM.htm>

#### 9.4 Appendix 4 - Marco Bischof Interview

Interview with Marco Bischof, conducted by Carlos Nobrega  
Berlin, February - 2006

Nobrega- The digital era seems to point that the only way to exceed the body's limitation is through technology. This is as if the body was limited by its physical condition. As if the body was obsolete. It is emphasised by the vision of some artists...

Bischof- Yes, I know. One of them calls himself Stelarc, I think?

Nobrega- Yes. But I think that I am trying to go the opposite way because I don't agree with that kind of vision. I think the body holds information that is somehow important to be considered.

Bischof- The problem is that these people think that the body is something primitive or is useless and has to be left behind or has to be improved. I believe the opposite. It is the case, actually, that the immense richness of the possibilities in our bodies is not used at all. There is much more in ourselves than we know. I think there are even many possibilities of future scientific developments hidden that we have not yet accessed, you know? So, I don't think it is good to move away from the body, the movement should be into the body, or into, not only the body but, the human being that we are.

Nobrega- I have heard that the heart can produce an electromagnetic field that is measured in terms of micro Tesla, using the SQUID. Is that right?

Bischof- Yes, that is right. There is one Institute in California which has become known for this research on the heart emission, it is the Institute of HeartMath [<http://www.heartmath.org/>].

Nobrega- Could you tell me what the relationship is between the production of an electromagnetic field by the heart and the biophotonic flux? [Bischof has written a book on biophoton research in German, "Biophotons – The Light in Our Cells"]

Bischof- First of all you have to know, biophotons can mean two different things. There are biophotons in the narrow sense, that's what we are measuring in our institute, which are only in the optical range, including UV, infra-red and visible light. Biophotons in the wide sense, on the other hand, refer to the whole spectrum of electromagnetic fields emitted by living organisms, all kinds of fields including microwaves and ultra-low frequencies.

Nobrega- Does it include brain waves?

Bischof- Yes, brain waves are also biophotons in this sense. Magnetic fields are also biophotons in this sense.

Nobrega- In my research I am interested in investigating the properties of these fields and their relation with the body. As an artist I think it is possible to create experiments with sensors that are sensible to these energies but I don't know at this moment which kind is suitable to use in that sense, especially because I do not want to be restricted to the laboratory.

Bischof- That is the problem because, you know, the instruments we use to measure human biophoton emission are big and cost hundreds of thousands of dollars, and you have to use a dark chamber because you have to shield it from the light around it because it is a very, very weak light. What would be possible, what would be interesting is if you take biophoton measurements and you transform them into another frequency range to make them visible. To make a picture which is not directly a picture of the biophotons but which gives you the image, making it a external light and transforming it in visible. You know, the instrument we use to do the standard biophoton measurements is called a photomultiplier. The photomultiplier is an apparatus that amplifies the biophotons millions of times. And thus because of this amplification you obtain an electric current that can be registered. But we also have another instrument, which is not used for the normal measurements because it is less sensitive, but the interesting thing is that you can see a picture of the light emission on a video screen.

Nobrega- And what would be that instrument?

Bischof- It is a CCD camera. A special CCD camera used in astrophysics, very, very sensitive. It contains a small chamber that you can make light-tight and into which you can put your hand, for measuring the light emitted by the fingers. We already did measurements of healers asking them to try to do the same thing they do when they are healing people with their hands and asking them if they can produce any light coming out of their fingers. With some of them it works, but only for a very short time. You can see this camera if you come to the summer school.

Nobrega- Could you say more about correlations between biophotons and the electromagnetic field? (15:49)

Bischof- Biophotons are always electromagnetic waves. [picking up a book to show me] These are images from the CCD camera. Do you see these leaves here? Here you see the lights from the leaves. This is called a "residual light amplifier".

Nobrega- Do these images appear directly in the camera?

Bischof- Yes, but the camera provides only brightness values and the computer transforms them into colours, therefore the colours are artificial, not what you would see. These are the needles of a tree, you know, these needles here are fresh and these are less fresh, after some hours. So, you can see how it [the luminescence] decreases as the vitality becomes weaker.

Nobrega- Are there any correlations between Kirlian photos and biophotons?

Bischof- Kirlian photos have nothing to do with the aura or biophotons. A Kirlian photo is not a picture of the aura. That's what many people say, but it is not true. Because what you



do in a Kirlian photograph is that you use a very, very strong electric impulse and this electric impulse will hit the skin and it will hit out some electrons from the surface of the skin which will then ionize the air and the ionized air will then produce the light.

Nobrega- Do you mean that this light is induced; is it not from the body?

Bischof- Yes, exactly, it is not from the body. But nevertheless it can give information about the body indirectly, but it is not a picture of the light coming from the body.

Nobrega- I have read about some experiments using simple digital cameras and image processing to register light emission in plants.

Bischof- Some Japanese researchers have developed different kinds of measurements. What we do is make our measurement as sensitive as possible to measure the intensity of this very, very weak light. But the problem is if you make it so sensitive then you can only get a kind of time information, not space information. What the Japanese do, they produce more a kind of photography or filming of the organism, and that means they are looking at spatial information, like how the light is distributed in space, but this is then much less sensitive. So, it is for different purpose. But the Japanese have developed very, very sophisticated instruments to do this. It was originally Professor Inaba who started this development, and now it is continued by people like Dr. Kobayashi, who is also a member of our institute.

Nobrega- What are the influences of the electronic environment (mobiles, computers, interfaces) on the biophotons emissions? I mean, nowadays we are living in a state of continuous connection with the electronic environment and electromagnetic fields. Is our biological field affected by it?

Bischof- Yes, of course. The biophoton emission will be influenced by everything. [...] You know about biological rhythms? You will find all these rhythms in the biophoton emission. Thus biophoton emission is pulsating, it is like breathing.

Nobrega- Because it is a quantum phenomenon?

Bischof- Yes, because every quantum emission shows a fluctuation.

Nobrega- Does the biophoton emission extend into the atmosphere, into the space outside the body?

Bischof- Yes, you have to understand, this radiation is very, very weak, but it is not like ordinary light, because it has the property of coherence, like laser light. Coherence occurs when you have two waves and they go in step, have the same phase. The interesting thing is that this light has a much higher coherence than any laser that is possible to make technically. It is highly coherent, and that means, because it is highly coherent it has almost infinite range, that means that a light that comes from a person ...

Nobrega- Goes to the infinite?

Bischof- Yes. There are certain quantum effects which only exist with weak light, but it must be coherent. And then you have very interesting effects, which are very different from ordinary light as we know it. There is a certain range within which the light that comes from my body, for instance, remains coherent. It doesn't stay coherent all out into space but stays coherent up to a certain distance, and within this distance, where it stays coherent, the light has very unusual properties. For instance, one of the consequences of this coherence is that, within the coherence range, the coherence of space-time, everything that is in the light, in this case, for instance, the cells of my body, will form one single whole in which you cannot separate, say, the molecules from the electromagnetic field of the biophotons and so on. Because they form one whole thing, you cannot separate any parts.

Nobrega- It comprehends the space. There is no space between?

Bischof- In a certain sense. Space and time do not apply in this area [of coherence]. For instance, light doesn't need time to travel in this area. It is instantaneous.

Nobrega- Is there connection between these events and Bohn's theory of the implicate order?

Bischof- Yes, it is a kind of implicate order, a dimension in which everything is connected to everything else and forms an unbroken whole.

[Picking up another book]

I want to show you something else, there is an American biophysicist who has written these two books. They are not about biophotons but they give a new picture of the organism which includes biophotons but also other similar electromagnetic aspects, vibrational aspects and so on. These books are the best you can find at the moment. [Energy Medicine: The Scientific Basis by James L. Oschman; Energy Medicine in Therapeutics and Human Performance by James L. Oschman; Bioelectrodynamics and Biocommunication by Ho Mae-Wan, Fritz-Albert Popp, Ulrich Warnke].

Nobrega- Does dowsing reflect any aspect of that field?

Bischof- Yes, but it has probably nothing to do with electromagnetic fields. I believe that our body has many types of fields, not only electromagnetic ones. Biophotons are only one type, one part of our field organism. Actually I have written another book about these non-electromagnetic fields ["Tachyons, Orgone Energy, Scalar Waves", 2002, in German]. Sometimes they are called "subtle fields" or a number of other names. For instance the Chinese qi, as in acupuncture, is probably not an electromagnetic field, but something else, maybe even more fundamental than electromagnetic fields.

Nobrega- I have been talking with a qigong practitioner who told me that qi is something that we can't tell about, just feel.

Bischof- But you know, even in physics there are some ideas about what type of field it could be. There are many novel types of fields, which physics is now looking into, and which are more fundamental than electromagnetic fields and have completely different properties.

Nobrega- And how have those fields been named?

Bischof- There are so many different names, like “scalar waves” or “tachyons”, but these names are not important, because presently we do not have enough knowledge to really give them a definite name. But you have to know that every type of physical field, especially electromagnetic fields, are actually products of the vacuum. Vacuum originally means “empty space”, but today we know that empty space is not really empty. It is a kind of universal field, the “vacuum field”.

Nobrega- Do you mean the “Zero point energy”?

Bischof- Yes, zero point energy is one concept of the vacuum energy. And that is what I wrote in this other book about.

Nobrega- Is it written only in German?

Bischof- Yes.

Nobrega- Are there connections between biophotons and these non-electromagnetic fields?

Bischof- Yes, that was what I said. Electromagnetic fields arise from the “zero point field”, they are a product of the “zero point field” of the vacuum. Do you know this book by Lynne McTaggart?

Nobrega- “The Field”? Yes, I have read it.

Bischof- She describes also biophotonics and the “zero point field”.  
[showing me another book]

This book is the proceedings of one of the summer schools we made, and there is a very long paper by myself at the beginning which may interest you. [“Integrative Biophysics: Biophotonics”, edited by F. A. Popp and L. Belousov]

I want to tell you a story. Prof. Popp did some experiments, some measurements on very small water fleas called Daphnia. They live in the water and are a little bit transparent. He measured a lot of these animals and he found out that if you vary the number of the animals that are in the cuvette, then you will see certain periodicities [showing me a chart]. The Daphnia, but only if you take Daphnia of the same age, from a certain stage of their development, will always have the same distance between them. And this distance is also a multiple of their size. If the Daphnia is like this size, then the distance will be two, three times this. And there are some other interesting phenomena, which led Prof. Popp to develop a theory about this. He believes that what happens is that these animals produce a field around all of them. The field possesses a certain wavelength; the animals seem to feel best when they are exactly fitting into these waves, into the pattern of the waves, when they are in phase. The interesting thing is that when they exactly fit into this pattern then you cannot measure any field. Only if the pattern is disrupted you will be able to measure light. Popp’s idea is that, and this probably applies also to human beings, we all live in a very big field which we do not perceive normally. We don’t know it is there and we cannot measure it. As long we are in harmony with this field you cannot measure anything. Only if the field is disturbed then suddenly you can measure something, because there is no more harmony. And this is probably the secret of this vacuum energy, of the zero point energy. We always live in this ocean of zero point energy, and we live in a certain pattern of this field - as long

as everything is in harmony, it is like nothing, the field is like it doesn't exist. But as soon as the harmony is disturbed, then you get these emissions, you can measure something, you can measure biophotons and so on. This is probably how the vacuum works, how the vacuum functions. It is a fundamental field, the foundation of everything. And we are always part of this field, and we need to be in balance so there is no tension, there is no problem. But as soon as we fall out of this balance then there will be emissions, indicating a disturbance. Because the same thing happens when we measure biophotons, for instance, of healthy people, healthy organisms or organisms that aren't ill. The interesting thing is that in the highest quality organism that is very healthy there is no emission, we don't measure anything. That means at the same time that there is a high coherence and no light comes out. We also measure biophotons from food, vegetables for instance. The highest quality food is the food that has very little biophoton emission. The fact that no light is emitted means that the lights remains inside. The body and the cells are able to keep the light, to store the light, and only then when there is imbalance the light comes out. Because the healthy cell will keep the light inside.

Nobrega - Do consciousness states interfere in this balance?

Bischof – All this has a lot to do with consciousness. Such a high state of coherence indicating health and optimal functioning of an organism is also measured in the brain waves which show your spiritual state, emotional state and so on. The interesting thing is that when you measure the brain waves of healers for instance, you will find the same thing; there is a high synchronization of the different parts of the brain in the healer. At the same time, healing only happens when there is also synchronisation between the brain of the healer and the brain of the patient. Some years ago, there was a researcher in the University of Mexico who measured the brain waves of people engaged in an empathic relationship. In this type of deep silent communication he found that the brain waves of the two people were highly synchronized.

Nobrega - Mr. Bischof, is there any important role of the heart in this process?

Bischof - Yes, the radiation of the heart can also be highly coherent. Scientists in the Institute of HeartMath [[www.heartmath.org](http://www.heartmath.org)] found out that there is a certain type of meditation where you concentrate on your heart and you try to feel loving feelings and so on and the waves of your heart start to become coherent, but at the same time the brain also becomes coherent and heart-brain synchronization is established.

Nobrega- Is it possible to externalise this state of coherence? I mean, create some kind of resonance between people?

Bischof- Yes, sure. I can show you some publications about it but you can also find information about this subject on the website [www.heartmath.org](http://www.heartmath.org).

So, how is the Transmediale?

Nobrega- It is ok. I liked some works, especially Simon Penny's machine. One robot interacts with the audience in a very "emotional" way.

[In 'Petit Mal' the media artist Simon Penny has created an interactive robot that does not have a useful function per se. This machine appears to be the diametric opposite of a hi-tech robot: it moves around light-footedly on the two wheels of a bicycle. Penny is interested in the emotional aspects of our relationship with machines, and in the cultural effects of research and development in the field of 'artificial life'. 'Petit mal' is a term borrowed from neuropsychology, and stands for a momentary loss of control. In a subtle way, this criticises the control paradigm and social application of computer technology, in that visitors to the exhibition are confronted with an elaborate machine entity that appears, like a young animal, to desire nothing more than harmless and playful contact. Petit Mal was conceived in 1989. Building and development occurred 1992-95. The robot was damaged during exhibition in Sheffield in 1998. In summer 2005 work began on resurrecting it for Transmediale<sup>136</sup> 2006. (Mondofunza 2006)]

Bischof- By the way, you know the following thing? I once was in an exhibition and there was a big cello and when a person was approaching the cello there was a sound and if you were approaching closer the sound was changing. You know? You can make an electric circuit where a person that approaches it will be included in the circuit and will change the flow of electricity, even at a distance.

Nobrega- Is it an effect of capacitance, isn't it?

Bischof- Yes, you are right.

Nobrega- But can I consider that capacitance reflects any way these fields we are talking about?

Bischof- Sure. Because, for instance, the capacitance of the acupuncture points changes when you are healthy or you are ill.

Nobrega- Does it mean that capacitance will vary according with biological state?

Bischof- I think so. But this maybe only works [the measurement] when you use very weak fields of current. Because if you use strong ones then there is no difference and then if you use the weak one you might find the difference. Here, in this history of bio-electromagnetism I also wrote about this field called electro-acupuncture. In electro-acupuncture you measure the electrical resistance of acupuncture points. And you will find that it changes according to the state of the meridian which corresponds to the state of health.

Nobrega- But in electro-acupuncture don't you introduce energy ton the acupuncture points?

Bischof- Yes, but there is not only therapeutic electro-acupuncture, there is also diagnostic electro-acupuncture. Therapeutic electro-acupuncture was developed in China, but diagnostic electro-acupuncture it was developed in Germany and Japan.

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<sup>136</sup> Cf. <http://www.transmediale.de/page/exhibition/exhibition.0.3.3.html>

Nobrega- Does that mean that I can use electro-acupuncture to get information from the body?

Bischof- Yes, it seems that you can.

### **9.5 Appendix 5 - DVD content**

The DVD constitutes of videos and pictures of the practice works developed through the study. The sections of the DVD are divided by the following titles: Breathing, Ephemera, Happiness, Equilibrium and Images. The chapter "Images" is a compilation of photographs from the presented projects.

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