Corporeal transparency and biomedical imaging technologies: a new scientific imaginary of the gaze

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"He was deeply moved by what he saw, or more accurately, by being able to see it, but he was also stung by secret doubts whether it might not be somehow abnormal after all, doubts about whether it was permissible to stare like this amid the quivering, crackling darkness. A deep desire to enjoy the indiscretion blended with feelings of compassion and piety".

Paul Thomas Mann, *The Magic Mountain* (1924)

Abstract

Visual information about the basic structures of the human body, technologically extracted and processed by ultrasound scans, computerized tomographies (CT), magnetic resonances, and positron emission tomographies (PET), produces a dense iconosphere that transforms the epistemological and relational basis of medical *praxis*. According to Foucault's work on the medical gaze and the spatial organization of illness, the contemporary imaging technology establishes new perceptual frames through which medicine can conceptualize pathological reality and the body itself. The outcome is a sort of *technological or artificial view*, a complex scopic system created by the imbrication of the eye with the instrumental device in use, which changes medical epistemology, relations, and practice while remaining firmly rooted in medicine's historical privileging of the visual as an investigative and diagnostic tool.

Keywords

Human body, medical gaze, scopic system, medical technology, ocular evidence.

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Transparencia corpórea y tecnologías escópicas biomédicas: un nuevo imaginario de la mirada

Resumen

La información visual sobre las estructuras básicas del cuerpo humano, generadas y procesadas tecnológicamente mediante *scanners* de ultrasonidos, tomografías computarizadas, resonancias magnéticas y tomografías por emisión de positrones, produce una densa iconósfera que tiene como consecuencia la transformación de las bases epistemológicas y relacionales de la *praxis* médica. De acuerdo al trabajo de Michel Foucault en relación con la mirada médica y la organización espacial de la enfermedad, la tecnología escópica contemporánea logra establecer nuevos marcos perceptivos mediante los cuales la medicina conceptualiza la realidad patológica y el cuerpo mismo. El resultado de todo ello es una especie de *visión artificial o tecnológica*, un sistema escópico complejo creado por la imbricación del ojo con el dispositivo instrumental, que modifica la epistemología médica, las relaciones y la práctica mientras que, a su vez, conserva y fortalece la prevalencia histórica en la medicina de lo visual como instrumento de diagnóstico y de investigación.

Palabras clave

Cuerpo humano, mirada médica, sistema escópico, tecnología médica, evidencia ocular.

Introduction

In one of the most influential works of the 20th century German literature, *The Magic Mountain* (*Der Zauberberg*), an outstanding and monumental novel created by Paul Thomas Mann who started writing it in 1912 (just 17 years after W. C. Roentgen's discovery of the X-ray), we have the opportunity of reading some significant and allegorical references to X-radiation and the impact exerted by the new medical iconography; that, upon the worldview and convictions of one of the central characters of the novel, Hans Castorp, when he observes chest radiography of his cousin, Joachim Ziemssen, performed by the sanatorium's chief physician, Hofrat Behrens, and then inspects his own corporeal form through the lens of the X-ray machine. Rather than an objective representation of the hidden morphology of human organism, for this generation of patients to which H. Castorp belongs, the first to experience the diagnosis processes of this revolutionary scopic technology after the Wilhelm Conrad Röntgen's Discovery, these radiological images were conceived like "intimate photographs" which, not only illuminated the internal physiological structures, but also captured the ethereal secrets of human soul. In spite of the historical distance, the medical imaging technology has continued being supported by a moral and ideological imaginary related to the life activities that permeates the public discourse (Johnson, 2008) and even the popular culture (Ortega, 2006) with a powerful rhetoric and a persuasive symbology that goes beyond the merely instrumental functionality.

From this point of view, the article constitutes, essentially, a philosophical reflection on the epistemological and sociocultural transformations that the modern imaging and visualization technologies have occasioned in medical perception of pathological phenomena and ontological status attributed to the body. My attention in this analysis will be primarily focused on the Foucauldian thesis, included in his already classic book entitled *The Birth of the Clinic: An Archaeology of Medical Perception* (2004), about the historical evolution of the spatial location and organization of disease in western medicine understood as an heuristic model that enables us to explore how the modern medical gaze has been modified by a new representation of technologically oriented body. In what follows, I address some epistemological axes of new visual paradigm that emerges because of the spread of digital technologies of visualization and its impact into the operative and perceptive basis of western medicine.

Firstly, I will show that the growing diffusion of modern medical visualization is the result of a longstanding tradition in western culture, from Platonic optical model to Cartesian scopic regime (or perspectivalism), which gives extraordinary primacy to the sense of sight as a

central instrument of scientific knowledge (Jay, 1992). The historical context of western visual culture allows us to discern how the dominant tradition of scientific vision is identified with medical strategies in order to surpass the opacity of human body. With the rise of modern visual technologies, this epistemic inclination has become more powerful and it is possible to find its connection with the praxis of contemporary biomedicine along the course of the last decades through two circumstances of special significance: the haptic distancing of medical practitioner from the body and the operative relocation of its representation into a digital emerging framework.

Given the centrality of technological instrumentation for modern medical observation, I intend to summarize the qualitative transformations related to the iconological representation of the human body and perceptive criteria to identify pathological disorders, insofar as they respond both to a new medical phenomenology as, on the other hand, to an extraordinary horizon of possibilities regarding medical diagnosis and prognosis.

Additionally and based on Foucault's archaeological theory of historical construction of spatial coordinates where the disease is visible, I will describe the epistemological implications of technical displacement of human physiology representation frames for the appearance of a new scientific conception and social experience of body. On the one hand, from anatomical theatre, laboratory or clinic, the body has moved to computer-simulated environments. On the other hand, the organic substance of human body is converted into a digital database with an enormous amount of information.

Finally and consistent with what was said in previous sections, I will draw some key ideas on how the medical image with its fascinating capacity to transgress the organic resistances of body and illuminate its hidden interior, contributes to expand the conviction of having achieved medical objectivity. With this presumption, it is inaugurated a medical imagery based on the illusion of witnessing, through contemporary scientific iconography, of life itself.

Historical background of the western scientific gaze

From its inception, biomedicine has conceptualized the world and humans within it through a mental gaze that was a "mirror of nature" (Rorty, 1980). The archetypical metaphor of the mind as mirror remains central to the basic epistemology of the natural sciences, producing a singular

experience that Jay (1992) links to the Cartesian "scopic system" (in which reality is a mental model derived from retinal images), through which it becomes possible to capture a "pure representation" of the "pre-existent world". This visual primacy in modern medicine sits alongside a commitment to the use of technology as a means of assuring medicine's essential scientific neutrality [1] . The specific ontology that underlies the contemporary medical epistemology is strongly reminiscent of what Daston and Galison (1992) have denominated as "noninterventionist" or "mechanical" objectivity that emerged in the latter half of the 19th century and beginning of 20th century with the proliferation of new forms of anatomical and physiological representation dominated by imaging technologies (photography, X-rays, lithographs, photoengravings, camera obscure drawings, radiographs, ophthalmoscopes, photomicrographs, etc.). Behind this revolutionary impulse (what was an innovation in degree), the representation of human body is subordinated to the control of technological mechanisms and, therefore, it is accomplished to exclude any subjective interpretation while it is glorified the empirical registration of signs and symptoms of human body pathology. Through early visual technology, the illusory ideal based on establishing an immediate relationship between the medical gaze and corporeal phenomenon without individual judgments or perceptive distortions is definitively accomplished. The medical image, as a modern emblem of objective truth, captures the pure morphology of internal tissues, bones, fluids, organs and muscles of human body exactly as it sees and nothing else.

The combination of visual primacy and technologically-enhanced scientific realism grounded a seemingly exponential growth of technologies designed to improve the human eye's ability to investigate the human body, which, ironically, widened the distance between the observer and the observed. Through such scopic technological discoveries of the mid-Renaissance as Galileo's *perspicillum* (according to Koyré (1968), the first scientific instrument), the eye lost its direct bond with its objects, but began to extend its dominance over other senses (Simon, 1988). The empirical basis of reality shifted from direct observation to observation mediated, and improved, by technology; hence a new type of gaze associated with

[1] As Waldby (2000) writes, because of its distinctive commitment to objectivity and realism, science investigates natural phenomena through the use of technological devices. Thus, for such philosophers of technology as Latour (1986) and Idhe (2001), scientific knowledge is produced by the instrumental reordering of vital reality whose parameters are historically contingent; as Waldby (2000) notes, the extension, scope and depth of scientific perception are regulated by the state of technological development that prevails at the time of investigation.

technological instruments[2]. Within medicine, the gradual advance of visual technology (e.g. illustrated textbooks, the microscope, the ophthalmoscope, the laryngoscope, photomicrography, and X-rays) furthered this historical transformation, and the *ethos* of "distancing" that accompanied it has become more powerful with the rise of modern visual technologies.

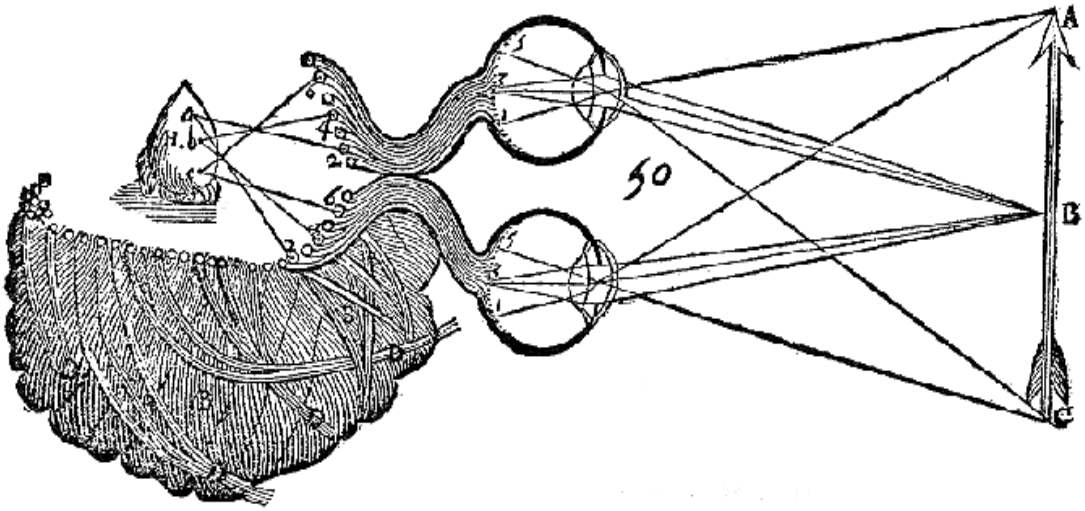


Fig. 1: R. Descartes, *Traité de l'homme*, 1662.

Twenty-first century medicine not only creates a new distance between medical investigation and the body (potentiating real-time consultations or robotic surgery at a distance), but reinforces this distance by situating medical *praxis* in computer-simulated environments (as in virtual medicine). As medicine visualizes the body's depth at the molecular level, its investigations, unit of analysis, and basis for empirical evidence move further and

[2] "Gradually, during the sixteenth century, draughtsmen ceased to record what they 'knew', and began to see in 'natural' perspective. Anatomical science arose out of hesitancy, and the subsequent denial of Galenic imagery that had been transmitted, not in pictures, but in texts. Truth henceforth was not what the eye has seen, but the result of observation. The use of the term, observation, is new; it designates vision with reference to an instrument. This amounts both to a degradation and an exaltation of the gaze: progressively, the eye itself was degraded into an observational device. Sight was disembedded from synaesthesis. Vision, thus made independent of touch or taste, was exalted as the main tool of observation. The eye lost connaturality with its objects and, at the same time, was assigned dominance over the other senses" (Illich, 1998, p. 10).

further away from organic flesh. Contemporary techno-medicine reinforces and re-legitimates the sophisticated primacy that this tradition attributes to visualization. While seemingly obvious, this is of crucial importance, as this new instrumentation of scientific visibility evokes a longstanding tradition (from Plato to Descartes) of vision as the main sense through which we can obtain access to the "true reality" of the world and the human body. Yet these new techno-images also, we suggest, represent a qualitative shift within medicine from translated depictions of underlying objective corporeal realities to perfect copies of them – images that are offered as neutral mirrors of life itself. This is a subtle difference, to be sure, but it has potentially massive consequences for the status of medical images as truth claims and, furthermore, for medical praxis, relations, and encounters. Thus, just as Wainwright et al. (2006, p. 279) argue that the "array of images that are a habitual part of the rhetorical repertoire of the biomedical sciences" merit critical examination precisely because "these pictures play a fundamental role in the social production and reproduction of biomedicine", I suggest that critical inspection of this "objective gaze", in accordance with Heidegger (1977), requires that we bracket and analyze both the integration of reality into a representational order under our control – a horizon of visibility and legibility - and the transparency and scientific decipherment invoked by visualization techniques.

Medical technologies and visual scrutiny strategies

Foucault's (2003 [1975]) work on the "medical gaze" in *Birth of the Clinic* documents the profound scientific power of the eye to visually penetrate the body's internal structure. He refers to this, according to Cartwright (1995), as "the technique of the corpse", as the autopsy becomes an extraordinary medical device for "discovering" evidence of disease in organs and organic cavities. Foucault problematizes the western anatomical view whose influence endures and, indeed, appears to be increasing[3]. Here, the Foucauldian concept of the medical "gaze"

[3] "Paradoxically, what I am terming the anatomical 'method' continues to live on in the twentieth-century informated environment and the nontactile age of the electronic machine. The computer-mediated milieu renders the body nakedly public. Pervasive monitors fulfil the promise for a transparent work-place latent in Jeremy Bentham's panopticon (1787). Similarly, one result of the new noninvasive imaging technologies in the area of medicine is the capability of turning a person inside out. If the late nineteenth century developed the photographic sounding of the living interior through endoscopy, gastroscopy, cystoscopy, and, most dramatically, X rays, the late twentieth century revealed its dark core three-dimensionally through MRI projections. Using

represents less the intentionality of perception than a distinctive historical style of perception, the outcome of a constellation of self-scrutiny strategies. Thus the gaze, rather than being either a focus that canalizes the disciplinary experience (as posited by some of Foucault's followers, e.g. Armstrong) or an objective encounter with reality (as assumed by science itself), conjures up a creative epistemological force that produces the subject as a live body that is then exposed to contemporary medical biopolitics[4].

While certain features of the human body could be seen with the naked eye, the awareness of an intimate relationship between the gaze and objective reality contributed fundamentally to science's long-standing effort to improve the observer's restricted vision – hence the optical instrumentation developed between the 17th and 18th centuries, designed to allow nothing to escape human enquiry or to evade human comprehension. Indeed, since the advent of modern western medical science, the transparency and evidence of human life have been advanced by biomedicine's increasing technological penetration of the body – first an initial incision and aperture of the body's inner depth, then through the abyssal layers of human physiology and anatomy. Upon opening new mysterious organic spaces, medical practitioners' gestures, habits and instruments transformed the scope of the gaze and inaugurated a key moment in which the objectivity of hidden physical or material topographies were associated with both scientific *praxis* and the powerful advance of optical technology (from the microscope to Positron Emission Tomography, or PET).

radio waves and magnetic fields, this technique for painlessly exploring morphology nonetheless raises the specter of universal diaphaneity. It conjures up foreboding visions of an all-powerful observer who has instant visual access to the anatomy, biochemistry, and physiology of a patient. Will this open-ended trend toward complete exposure give rise to same sense of vulnerability, shame, and powerlessness that the eighteenth century associated with anatomization?" (Stafford, 1997, p. 48).

[4] "The point to be made here is only that the notion of the gaze is not deployed in *Birth of the Clinic* as a kind of *deus ex machina* predetermining everything that happens. Nor does the gaze represent a reductive mode of perception, as an anti-medical perspective might encourage us to expect. On the contrary, that gaze is productive of individuality, uniqueness, particularity" (Osborne, 1999, p. 35).

Fig. 2: Andrea Vesalio, *Humani corporis Fabrica*, 1543. Frontispiece.

This vast increase in the body's visibility – the medico-technological representation of life at the molecular level, and of mental and even emotional processes at the neural level – is, again, causing a deep break with conventional modes of scientific vision. We are witnessing not only a growth in the ability of the medical gaze to penetrate the body but perhaps, a complete transformation in medical representations of it, or, in Foucault's (2003, p. 241) words, a new syntactic "reorganization of disease in which the limits of visible and invisible follow a new pattern". The perceptive fascination that produces, in classic medical epistemology (Persaud, 1997; Sawday, 1995), the evidence of the open body (Renaissance: Vesalio, 1543; Valverde, 1586) has produced an incipient projection of a "Neo-Vesalian" base (McKusick, 1989) erected as an archetypical emblem of contemporary medical techno-science. More importantly, as Idhe (2001) demonstrates, this shift in ways of seeing the body is deeply connected to a hermeneutical style of observation which transcends the "natural" capacity of seeing. Thus we

have a transition from an analogical gaze to a new gaze formed by the computer's capacities to process and represent a form of digital imaging – in other words, from an image without digital treatment (an analogous projection of represented reality) to an image as a finite set of digital values (picture elements or pixels) which one can manipulate, *via* computer, in multiple ways.

The consequences of this for medical knowledge, relations, and *praxis*, while beginning to be examined, are still not fully understood. These shifts may, however, signal a sea-change in how medical images – and medical knowledge itself - are constructed, understood, and deployed. For example, in addition to the practical technological extension of vision beyond traditional boundaries, we now have new qualitative criteria (above all, the key idea of *life as exploitable and computable information*) for how to technologically generate the visible body that offer a novel way of perceiving flesh and life. But this new gaze, I argue, signals a new medical phenomenology that is greater than the sum of its parts: it constructs a specific cartography of the body, centring on its carnal depth. The search for the truth through the medical gaze leads to a search for the body's basic, hidden layers. Here we are in the realm of a singular representational style: when the "eye of science" observes the body, it seeks to transcend the simplicity of the immediately visible to discover the unseen – and traditionally invisible – underlying order[5]. With these developments, the medical gaze has not lost its power but has, instead, been reorganized and intensified through the generation of coded maps and digital images, generating visual horizons that reinforce (and, purportedly, advance) medicine's capacity to diagnose and predict. In short, new visualization techniques constitute a subtle challenge to established medical organization insofar as they establish a different way of seeing in the epistemic universe of the trained eye, and this new way of seeing fashions new representational spaces and new relations between medical agents, on the one hand, and doctors and patients, on the other.

[5] Cited in Kuriyama (1999, p. 128).

From anatomical theatre to virtual theatre: a new medical representational regime

While contemporary medical imaging is confined to the computer's screen, it is in that digital and electronic context that the medical gaze surpasses natural laws associated with the natural capacity of the human eye. The doctor's gaze is no longer a conventional one, but an artificial gaze which can travel across any section, organ, or tissue of human body, from any perspective and moment, because *the body itself becomes a (digital) archive* that can be manipulated to construct certain underlying 'truths' about it. Medical imaging thus appears in a new representational space. The body's newly-discovered capacity to be archived and processed as a database supplies a new spatial and topographical ordering in which the criteria for presentation and visibility have been transformed. This complex archived body resides in a digital context, the computer screen, where its iconological projection is subject to a new technical and narrative organization.

Clearly, this is the result of a historical mutation of the material and epistemological ground in which medicine rendered the human body visible. As Waldby (2000; Carroll and Waldby, 2012) argues, the traditional anatomical theatre has been replaced by another theatre with its own optical and symbolic logic. Nowadays, autopsies are increasingly performed in a virtual and web-based theatre which can be downloaded onto individual computer terminals. In this new digital space, the corpse, already transformed into a database, can be endlessly presented from any perspective and position without being subject to physical decay.

According to Thacker (2000; 2005), the traditional anatomical theatre's representational strategy emphasized "ocular evidence" derived from both the dual authorities of anatomist and text and the introduction of the corpse to a spectacular architectural scenery[6]. Behind the

[6] "Dissection is a practice, informed by anatomy and medicine, and as such it is composed of a range of techniques, tools, subjects, texts and modes of objectification. Though there was not necessarily one single mode of dissection during the early modern period, their commonality lies in the ways in which the various techniques of dissection contributed to the formation of an anatomical body as their primary goal. Every cut is strategic here, as an art of making the interior visible to both anatomical science and (in the anatomy theaters) to the naked eye of the spectator. The process of dissection is thus a constant negotiation between a potentially disarticulated corpse and the scientific rigor of the anatomy text. The body that develops during this phase - the 'dissected body' - is constantly being incorporated into the anatomical frame, though as a literally opened, unbounded and grotesquely visceral form, it may also threaten the coherence of that same framework. Again, there is a unique type of distance or space articulated here within the dissected body, situated between the corpse and the anatomical text or, more

anatomist's analytical gaze, the isolated corpse in the theatre announced a symbolic and spatial recomposition of human flesh, ready to be studied through dissection. At the centre of this space, dissection articulated the distances and relations between the exposed corpse and the content of anatomical texts. Thus, the anatomical theatre inaugurated a symbolic universe that channelled cultural and epistemological aspects of that era's medical science on several levels: in addition to religious, cultural and emotional links between the corpse, the anatomist and the public, this theatre embodied the cognitive logic of a neutral gaze inspecting the interior of a dissected body, understood as scientific object. The paradigm of new anatomical science made plausible a new organization of the medical eye which transcended the dialectic, in medical knowledge, between text and anatomist (*disputatio* or *demonstration*). Indeed, under the influence of Vesalio and other anatomists, this new paradigm validated the perceptual organization of the corpse's opening on the basis of three axes which Sawday (1995) has identified as text, body and anatomist (here, body/anatomist relation increases in importance becomes more important as importance of the text becomes less evident).

Contemporary medical imaging, however, represents the body in a very different way. The break with the hitherto prevailing scopic regime has fundamentally altered how we understand the body – specifically, it has brought about an epistemological shift in the oppositional relationship between the external density of skin and the internal human body.

As Cartwright (1995) and Crary (1998) have shown, *via* Foucault, the discovery of the reality of life beneath the body's traditional opacity was inseparable from a profound shift in how the nineteenth-century observer explored the human body's somatic interior[7]. Indeed, for Foucault, the nineteenth-century transformation of the visual horizon of the medical gaze (identified with Cuvier's works) helped to modify the cognitive conditions that led to the emergence of new objects in the corporeal cavity and, implicitly, of a new anatomical rationality [8]. Foucault's insights not only demonstrate his powerful interest in visual

specifically, between the technical implementation of anatomical discourse and anatomical discourse itself" (Thacker, 2000, pp. 326-327).

[7] "Foucault states that the shift from eighteenth-century natural history to nineteenth-century biology is marked by a change in relationship between representations and things. The emergence of 'life' thus is accompanied by the emergence of a new mode of representation". (Cartwright, 1995, p. 10)

"With the emergence of biological modes of representation, we find a historical break between observation (or image) and object of knowledge-a break in which the visualization of 'life' becomes all the more seductive to the scientific eye even as limitations of representation are made plain" (Cartwright, 1995, p. 10).

[8] Crary (1998, p. 16) explains that this shift centred on the removal of subjective vision from "the incorporeal relations of the camera obscura and [its relocation] in the human body. It is a shift signaled by the passage from

phenomenology expressed in his view of biological and medical life, but provide us with an illustrative key to how our way of seeing the body is intimately tied to how we spatialize and stratify illness – a process that is historically contingent.

Fig. 3: Juan Valverde de Amusco, *Anatomia del corpo humano*..., 1559.

I suggest that the Foucauldian spatial approach to illness might be a useful resource for examining modern medical imaging. On the one hand, techno-medical visualizations continue medicine's longstanding need to make visible all aspects of carnal opacity; on the other hand,

the geometrical optics of the seventeenth and eighteenth centuries to physiological optics, which dominated both scientific and philosophical discussion of vision in the nineteenth century".

we are witnessing a fascinating change in the spatial models of depicting somatic depth[9]. What makes Foucault's contribution (*The Birth of the Clinic*) particularly useful here is his insight that the ontological schemes regarding illness rested on a strategically configured spatial background. This is central to our argument precisely because Foucault demonstrates that illness comes into existence against a background of metaphorical vectors (Sontag, 1990; Herzlich, 2005) and iconic grammars that vary historically. Here is the heart of Foucauldian theory, insofar as tracing the historical evolution of a specific conception of pathology or medical knowledge in general becomes not only a process of historical documentation but a heuristic device designed to highlight changes in how we conceptualize, understand, and represent life and illness (Bauer and Olsén, 2009; Webster, 2007).

Foucault's reading is useful on this point, because contemporary biomedical imaging technology requires a new medical gaze, trained to decipher signs, marks, and forms not only of the human body *but of its digital copy* projected through the computer screen. This gaze thus has two features that distinguish it from the gaze that prevailed in the traditional anatomical theatre. First, it requires the observer to reorient her gaze from the body to the computer screen. Here we have a new spatialization of disease, and thus a new distribution of illness (that is to say, a new relationship between the space wherein illness is configured, and the space wherein illness is physically located). Second, identifying disease through the use of imaging technologies presupposes the mastery of interpretive codes of configuration and localization in accordance with specific semantic rules (e.g. anatomical knowledge, colour differentiation, and contrasts).

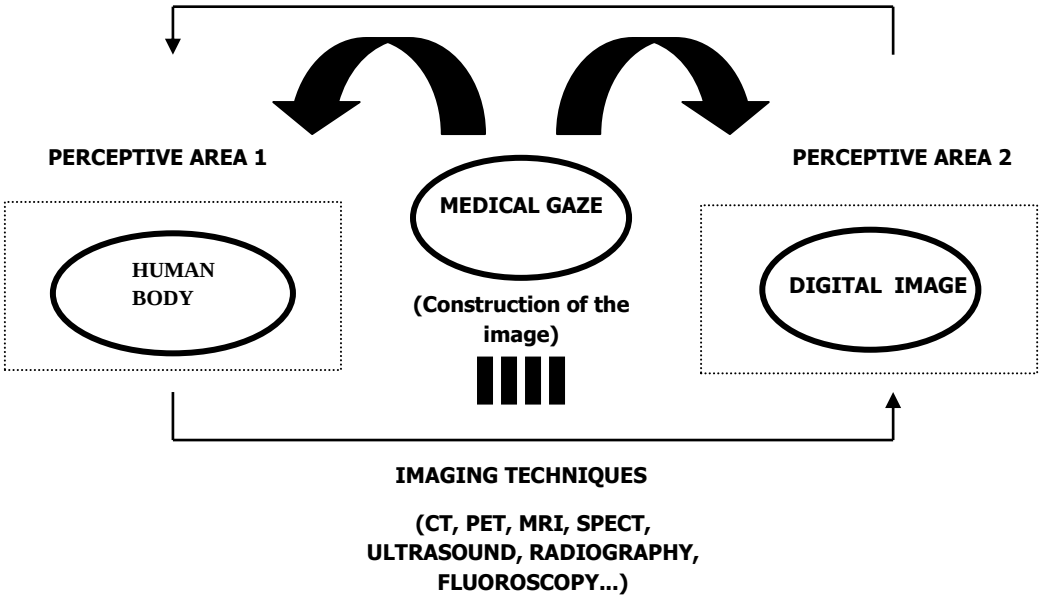
From organic to digital bodies: the new objectivism

New medical imaging technologies also introduce a complex mental process of association based on the premise that the screen displays what is actually occurring inside the body. However, there is not, in fact, a neat overlap between perception and the presumed

[9] "Indeed, Foucault's opening differentiation of primary, secondary and tertiary spatialitation of illness (a sort of cognitive, corporal and geographic map) provides an excellent device for explaining more recent changes in the nature of illness" (Armstrong, 1998, p. 22).

"perceived" corporeal reality. Despite their bonds and connections, these represent two different orders of visible bodies: the organic body, and a technologically constructed one that invokes and represents it. The perceptive area that is the human body is translated, *via* imaging technologies, into a digital image; the medical gaze now examines a *digitally rendered body* rather than the three-dimensional, *organic one* that constituted the focus of the traditional anatomical theatre.

DIAGRAM: DIAGNOSTIC IMAGING



In terms of both space and time, then, biomedical technology introduces new properties and topologies to the iconological organization of bodies, and this shapes the epistemological character of scientific objects themselves. When generated by virtual reality systems (for example, the virtual endoscopy (Robb, 1996) or other visual archives such as VHP), some of these medical images *gain status as scientific objects in a non-static geometry or topography* – in other words, because of, rather than despite, their malleability. On the one hand, the perspective from which the body's interior is observed can be changed at will (as if the space surrounding the body were itself an optical scene), and, on the other hand, such flesh is itself "fully morphable" – changeable through technological manipulation. Thus the body is always virtually transformable because it is reduced to visual information processed by computers. As Cartwright and Goldfarb (1992, p. 138) write, "Digital images have the quality of limitless

mutability without loss of information density. They can be repeatedly changed, modified and manipulated without a loss of quality and without limits. The virtual anatomy is open to almost any kind of manipulation, because any action performed upon the body is reversible and free of consequences"[10]. Early technologies that medical agents used to extract information from the body measured vital signs and presented them in abstract form (e.g. assigning numbers to, or depicting on graphs, vital signs such as respiration, circulation, and heat), and this, according to Reiser (1978, p. 91), "transformed the functional actions from subjectively monitored phenomena (such as impressions gathered from pulse-feeling), to objective events several observers could jointly evaluate and discuss".

Despite having replaced the impression-based diagnosis alluded to above, and despite having improved diagnostic accuracy, however, information registered in electrocardiograms or thermometers merely translated organic function without actually capturing, in a direct way, the body's interior. In contrast, new medical imaging technologies create images "of" bodily processes that take on the status of objective representations unmediated by subjectivity, evaluation, or technical translation. Modern medical imaging thus surpasses the historical conversion of the human body into standard data by conducting a second conversion: from digital *information* (translated into binary language) to digital *images*. In technologically generated images, then, modern medicine finds seemingly incontrovertible support for its claimed identity as a science based on objective, empirical evidence.

Medical imaging reinforces this claim by offering a set of images which it presents as pure iconological copies of the body's inner state, rather than numerical or graphic translations of it. While scholars such as Moore and Clarke (2001) and Petersen and Regan de Bere (2005) have documented the ideological nature of digital images, the rhetorical and persuasive force of these images communicate objectivity by their tacit claim to having captured reality through an unmediated photographic process[11]; the digital image as an "objective reflection of human flesh" subtly transmits a realist conception of not only the human body but life itself.

[10] [Tomography attempts] to map the space of the body in planar projections, each plane constituted as the sum of a multiple set of geometric projections...the extreme reduction of the focal field counteracts the spatial imprecisions introduced by standard photographic perspective. It can be argued that [tomography] does not simply correct perspectival space, but introduces an entirely new model of spatial representation. The [tomography] image is less a pictorial record of appearances than a means of measuring an abstract, non-visible property of the body: volume (Cartwright and Goldfarb, 1992, p. 193).

[11] In their more recent study of cyberanatomies, Moore and Clarke (2001) found a continuing bias against the clitoris, which remains largely invisible or portrayed as nonagentic in this media. Although the Internet would

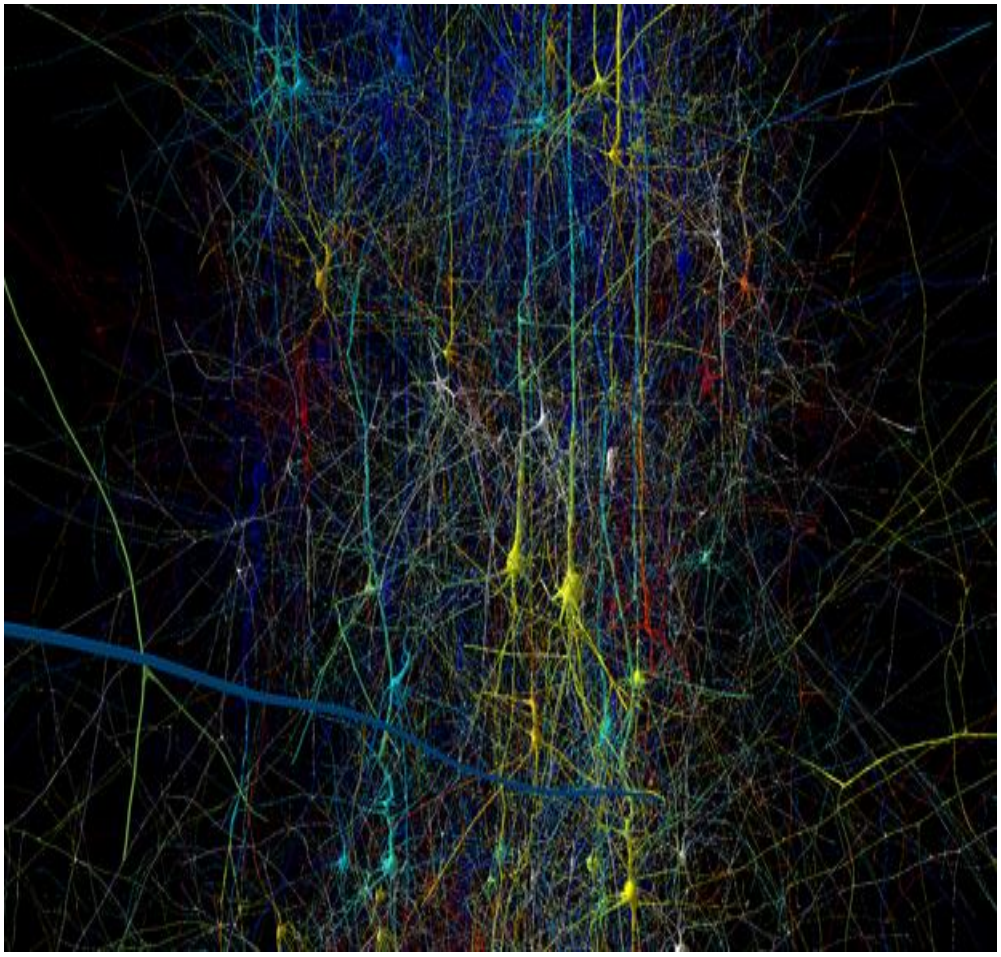


Fig. 4: *100 Neurons being simulated*. Courtesy of Visualbiotech, 2006-2008.

Medical technology thus *modifies the status of the image in medical science* in both technical and symbolic ways. First, physiological signals can not only be transformed into standard codes, as was the case before the advent of new medical imaging, but can now be transformed into computerized information from which digital images that "neutrally reflect" physiological phenomena can be produced. Second, the objectivity that medicine traditionally

seem to provide the potential for alternative anatomical representations to counter the traditional biomedical genre, as the authors conclude, "popular alternative genital anatomies, including feminist anatomies, remain comparatively rare, isolated and difficult to locate" (2001, p. 85). Further, Petersen's (1998) study of *Gray's Anatomy* from 1858 (first edition) to 1996 shows that anatomy has remained largely impervious to broader public debates about sexual inequalities and gender representations during this period".

attributes to standardized information (e.g. graphs and statistical tables) extends to the digital image, which is itself associated with organic reality, but in magnified form: the objective reality of the body can now be captured directly rather than referred to. The gulf between the objective body and its representation has been bridged by technological fiat.

Underlying the scientific validity of medical imaging is a tension between the idiosyncrasy of individual bodies and the essential biological truths that transcend them. This tension, and its resolution, predates these new technologies, as Foucault documents in *Birth of the Clinic*: the medical gaze, which uncovers hidden truths by allowing the doctor "to communicate with the ontological order" (7), treats the order of disease as "a carbon copy of the world of life". The medical gaze recognizes that the patient is incidental, as disease occurs despite biographical idiosyncrasies, which must be disattended in the interest of objective investigation: "It is not the pathological that functions, in relation to life, as a counter-nature", Foucault writes, "but the patient in relation to the disease itself". By the same token, the doctor's natural tendency to focus on the patient-as-individual is a potential distraction, unless "his intervention (…) is subjected strictly to the ideal ordering of nosology" (8), and the result is that both doctor and patient/body "are tolerated as a disturbance that can hardly be avoided" (9). One solution to the resultant tension between the general (underlying truths) and the specific (the idiosyncratic biographies and social tendencies of patient and doctor, respectively) is the observing gaze, which "manifests its virtues in a double silence: silencing theory, distraction, and imagination, on the one hand, and all senses besides that of vision, on the other" (pp. 108-109).

Thus these medical imaging techniques invoke the premise that in these images we see, not images of life, but life itself. These visual technologies fashion a biomedical imaginary in which the boundaries between the organic and the inorganic, original and reproduction, are fluid. This "illusion of life" has interesting epistemological consequences. For example, in the field of neuroimagery, representations obtained by PET or fMRI are being interpreted as definitive proof against mind-body dualism, as they "capture" a vital dialectic between brain structure and cognitive functions (Posner and Raichle, 1994). Thus, certain interpretations about neuroimages stimulate the idea beyond scientific communities that these new techniques can represent our thoughts, reinforcing neurophysiological reductionism, because logically neurology only can infer mental activity *via* images of brain's material structure.

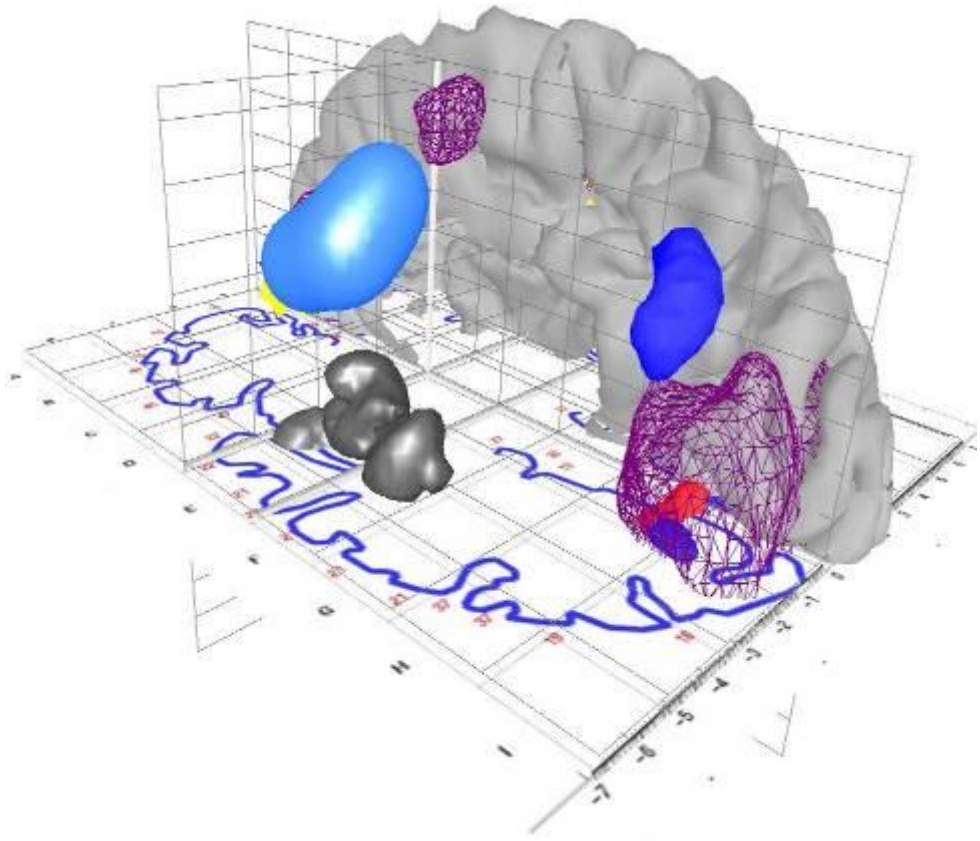


Fig. 5: *VRML Image of Brain Activation*. Heather Drury, 2000. Courtesy of THOR, Center for Neuroinformatics.

In this sense, it could be very interesting to consider the anthropological approach developed by Dumit (2003; 2004) in relation to social meaning of brain images. Far from being self-explanatory, transparent and a univocal reflection of neural structure, the images generated by positron emission tomography scans are the result of complex algorithmic processes and sophisticated statistical and digital construction systems. But Dumit goes beyond this evidence and problematizes the strategies of objectification that are manifested in this kind of scientific images by exploring the cultural dimensions and the ideological role played by brain images in mass media, insofar as they have become a regulative instrument that has a deep incidence into the coactive and disciplinary strategies of contemporary biopolitics. Attending to this perspective, Dumit argues that brain images, as conventional emblems of medical diagnosis and objective-self fashioning, could be also understood, on the contrary, within a cultural, historical, mediated, institutional or even narrative (Matthews & McQuain, 2003) as well as a scientific and biomedical context. Rather, the brain image appears to be an efficient device in

order to demonstrate the biological background for mental illnesses, behaviours, emotions, depressions, addictions, desires, criminal comportments, etc. (Dumit, 2003). Thus, the brain visualized in scan becomes a biosocial space (according to the notion of Rabinow, 1992) which enables the embodiment, the maintenance of desirable selves (Johnson, 2008) and the construction of personal identity in terms of its boundless capacity of individual categorization. That is why Ortega (2009) speaks of this process of neurological subjectivation as "neurobiologization of selfhood", that is to say, the translation, in contemporary biomedicalized societies (where neuroscientifics claims are spreading within dominant public discourse in terms of what Foucault calls 'technologies of self') of subjective universe of individuals into cerebral manifestations.

Griffiths (2010), in her study about screening techniques for diagnosis of breast cancer, describes similar aspects when he considers that mammography visualization with X-rays symbolizes, not only an expression of the maximization of health understood as an ethical value and moral obligation (Rose, 2007), but also a microtechnique of social control, of normative management and construction of gender and sexuality. But, in many cases, as it occurs with cervical screening (Howson, 1999), bone scans (Reventlow, 2006) and other kind of optical diagnosis that specifically focuses on different parts of body, mammography tends to generate a distance between the patients and their bodies, as well as a no completed embodied experience, insofar as the body itself is represented as fragmented.

The new properties and topologies that biomedical technology introduces to the iconological organization of bodies also shapes relations between medical agents, between doctor and patient, and between the patient and her own identity and care. First, the space of visual computation *disrupts the network of relations* that inhered within traditional medical *praxis*. If, as Sawday (1995) argues, the anatomical theatre, or "biotechnical space", housed a triangular confrontation between body, anatomist, and text, today's computational mediation replaces the organic body with a virtual, digitally generated one within a "holotechnical space", enlarging the distance between the observer and the medical object. In this new technological frame, the centrality of touch is replaced by vision (although most medical imaging technologies are also being used to generate surgical simulation techniques, providing a surrogate body part on which surgeons can be trained, using haptic feedback systems). Second, the *inner body's intelligibility* no longer hinges on the medical investigator's direct visual and tactile encounter with the body's exposed interior, but relies on digitally mediated projections. Rather, such images are rooted in an "exscriptive technology" (Lippit, 1996): one that writes the living body's interior morphology as externalised image-objects, traces or reflections projected onto screens.

Thus Waldby (2000) notes a clear difference between radiographic and tomographic inscriptions: while the X-ray produces an image in which the surface levels and the opaque shadows of the body's interior are confused, the tomographic method eliminates the radiographic merging of levels by flattening the body's depths into an exteriorised interior.

The images of these techniques produce rhetorically the idea of "objective neutrality" to the doctor-patient relationship ("A picture is worth a thousand words"). Although, as Barley has argued (1988), images are structured by a complex semiotic language which is the exclusive remit of medical agents, as visual representations of reality these images resonate with an extra-medical cultural repertoire and the diagnoses (and prognoses) that they represent are more easily grasped – and less likely to be contested - by patients than are more rarified medical charts, graphs, and linguistic constructions. This "objective neutrality" may also cause the patient to have greater faith in medical diagnosis and regimens. A patient examined by the application of this sophisticated medical imaging technology may be given the impression that the resultant images have been captured in a context that renders subjective interpretation or technical error improbable, if not impossible. This may encourage faith in medical diagnostic procedures, and compliance with medical directives "based on" this "objective evidence" of the underlying condition; moreover, the perceived instrumental effectiveness of visual technology may mitigate or even counteract the gradual loss of doctors' professional authority (see Wilkerson, 1998; Broekman, 1987; Navarro, 1986; Waitzkin, 2001). The patient may come to feel, through the persuasive force of technologically generated images, as if the visual identification of processes occurring within his body places him on an equal footing with the doctor in relation to medical discourse when, in reality, the capacity to interpret medical imaging remains the latter's exclusive property.

Furthermore, medical imaging opens a vital space that had been previously hidden from the patient, and can thus be linked to Foucault's "technologies of the self", as it encourages the patient/subject to see herself as an object in the course of deciphering images of her body's inner space. Finally, scopic technology hastens the diminution of the role of touch in medical diagnosis – a process that began with the introduction of X-ray technology in 1895 (Reiser, 1978, pp. 63-64). Gradually becoming a more central feature of conventional diagnosis, this technology helps to regulate physical contact with the patient.

Medical imaging also shapes medical practice outside of doctor-patient relations. For example, it allows for an *improvement of human capacities in medical operations*. Visual technologies have become essential support instruments in high-precision procedures and, in this sense, help to overcome certain limitations in doctors' technical skill. For example, thanks

to computer screen support, laparoscopic surgery and robotic surgery has quick developed (these techniques are known as hands' extensions and eyes' miniaturization). Thus, the *Da Vinci* and *Zeus* Robotic Surgical Systems developed minimal invasive operations through computer assisted surgery and endoscopic cameras. At the same time, medical virtual reality is becoming increasingly important for preoperative planning and for training simulators (designed to reduce the risk of surgery). Finally, as computerized data, digital images can be sent in record time over internet and, therefore, can allow not only remote diagnosis and consultation but the execution of distant operations from remote surgeon workstations as well. This is an interesting dimension of medical imaging that could significantly change the organizational structures of medicine in near future. Technomedical images are not only structured by emerging digital spaces, but generate a new spatialization of medical relations (from diagnosis to prognosis, therapeutics, and the social organization of health care).

A new medical imaginary

In the context of digital imagery, the *symbolic universe* visible in classical anatomical illustrations and that linked the anatomical body to such other important human events as *memento mori* or *vanitas* is effectively erased, replaced by an empty aseptic surface on which the body is depicted as an isolated, organic entity. While this former universe survives in the cultural realm, the representational domain fashioned by new medical imaging technologies grounds a new imaginary in which nature and technology meet to produce a post-natural order.

Consider, for example, echography, which Barthes (2000) argues is a particularly strong example of the display of sophisticated medical imaging technologies' rhetorical potential not only to construct identities but to become an authentic spectacle of popular science (3D and 4D rotation echographies were heavily used in the internationally-famous National Geographic film titled "In the Womb" (2005), which follows the development of a human foetus from fertilization to birth). Echography transcends the conventional boundaries through which the identity and even gender are culturally constructed: while a photograph of a baby being born once constituted the first iconological record of a human's social beginning, this beginning is now recorded, *via* echography, in the womb. Once distributed by mass media, scopic technology thus produces medicine as a strategic arena for self-experimentation and identity construction. In this sense, Rapp and Ginsburg (2007) confirm this argument by pointing out

that emerging synergy between visual technologies in the field of reproduction, from pre-conception to neo-natal care (ultrasound imaging, sonograms, genetic diagnosis, 3D or 4D ultrasound scan, fetal doppler, non diagnostic sonogaphy, etc.), and the visibility of new-born in the popular mass media, not only reinforces the medicalization of reproduction beyond the maternal womb, but also contributed to create an emergent social logic of scrutiny that extends into the realms of what Berlant (2000) has called "public intimacy".

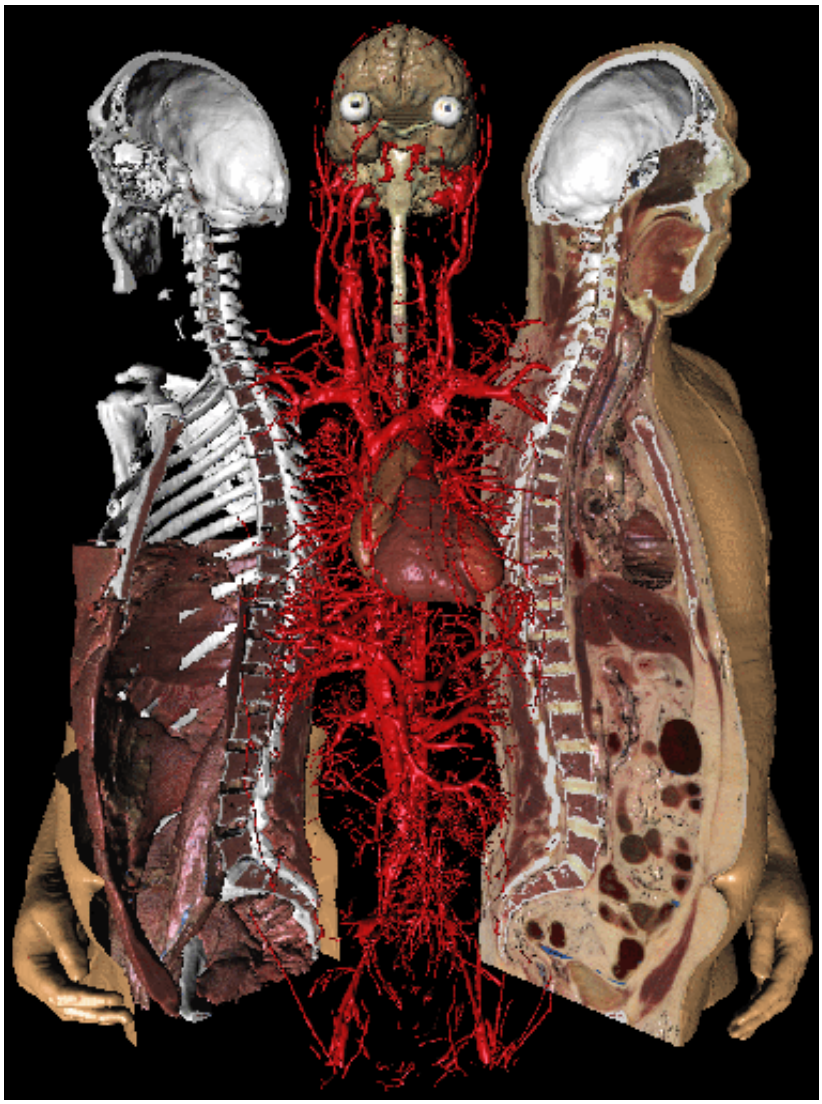


Fig. 6: F. B. Sachse, C. D. Werner and G. Seemann, *Simulation of Cardiac Electrophysiology and Electrocardiography*, 2001. Courtesy of Meetman Project, University of Karlsruhe.

Clearly, then, new technical imaging affects not only biomedicine and other scientific fields, but popular culture and lay understandings of science and the body, as it appears in such extra-medical realms as the mass media, artistic movements, and the internet. How the lay public interprets scientific information and, most relevant here, scientific and medical images has been examined by a range of scholars (e.g. Collins and Evans, 2002; Epstein, 1996; Webster, 2007), who uncovered a complex interpretive process informed by distinctive meanings, beliefs, codes and relevances embedded in the lifeworld. Thus, the scientific claims reflected in these new technological images would take on new meanings when interpreted by the lay public. Yet the lay public's translation of medical images is rooted in the biomedical imaginary and partakes in a long, distinctively western, cultural and narrative tradition, as a deep rhetoric projecting collective metaphors of the body, the relation between nature and technology, the life and death, time, and so on, grounds these images. Thus, the new visual experience that medical imaging creates rests not only on scientific constructions, but on broader social and cultural traditions; as a result, the image is an important instrument for scientific practice and a vector for a social imaginary[12]. That is to say, the representational strategies of contemporary technology drive the creation of a "biomedical imaginary", which Waldby (2000, pp. 136-137) defines as "the speculative, propositional fabric of medical thought, the generally disavowed dream work performed by biomedical theory and innovation".

A scientific development that has inspired particularly intense reflection, and shored up an imaginary, near-futurist universe, is the convergence "cybernatural" (Cubitt, 1996) - a form of post-natural life that is the outcome of the mingling of the *force of life with the force of information*[13]. Cubitt (1996, p. 238) points to a new "ontological" category that makes it difficult to detect the boundaries between the organic and the artificial. Visualization techniques, along with a "whole range of technologies for decomposing, anatomising, amplifying at molecular level", have not only inspired a cybernetic turn in contemporary medicine, but have also participated in a singular ontological change that Rose (2007) calls "molecular ontology". This depends on an epistemological background from which it reinforces

[12] "Cette lente érosion du rôle de l'imaginaire dans la philosophie et l'epistémologie occidentales, si elle a bien, d'une part, assuré l' énorme essor du progrés technique et la domination de cette puissance matérielle sur les autres civilisations, a d'autre part, doté 'l'adulte blanc et civilisé' d'un particulisme marqué, séparant ce dernier et sa 'mentalité logique' du reste des cultures du monde taxées de 'prélogiques', de 'primitives' ou d' 'archaiques'. Durand, G. (1994), *L'imaginaire. Essai sur les sciences et la philosophie de l'image*. París: Hatier.

[13] Waldby uses this concept to assert that "the cybernatural designates any practice which uses the space of the virtual screen as a space of 'second nature' through a conflation of information with vitality" (Waldby, 2000, p. 121).

a range of interventions into daily life to control vital processes; through these interventions, the human body becomes increasingly subject to technologically accurate and biomedically precise enhancement, to the extent that the body begins to incorporate prosthetic and biotechnological extensions or replacements, inspiring speculation about post-human future and the emergence of a new human/cyborgian nature (but see Rose, 2007[14]).

Fig. 7: *Human embryonic stem cell (gold) growing on a layer of supporting cells (fibroblasts)*. Courtesy of Annie Cavanagh & David McCarthy. The School of Pharmacy, University of London.

[14] "Recently, the idea of the Cyborg has entranced social theory - the cyborg as a fusion of human and artefact (Gray, Haraway). But I think that the artificially enhanced bodies and minds that I have discussed do not conform to the idea of the cyborg. While mechanical augmentation, robotics and computing seem to make the human being *less* biological, the new molecular enhancement reshape vitality from the inside: in the process, the human becomes *all the more* biological. Life becomes mechanism- our biology itself is the subject of re-engineering." (Rose, 2007, p. 11)

Conclusion

While deeply resonant with the pivotal, privileged position that western science has attributed to vision over the other senses, and to the enmeshment of vision with enhancing technologies, the new artificial view that characterizes modern medical techno-science fashions new epistemological, representational, and relational spaces in which medical science and care play out. Medical imaging does not cause an epistemological break with scientific inquiry but reinforces it by continuing to conceive of the world as something that can be "purely represented". Medical imaging traces all the inherent possibilities of science as "phenomenotechnique" (Bachelard, 1953); in other words, the emergence of a scientific phenomenon (here, the human body) appears embedded in a network of visual technologies. Thus, medical imaging becomes one of the most important rhetorical tools for organizing scientific research and for shaping a new articulation of the organism and of life.

One of the strongest arguments for this has been these technologies' complexity and operative capacity. As we have seen, modern medical imaging can penetrate the material opacity of the body without the "literal, material transgression" (Keller, 1996) of human flesh that has been traditionally necessary to generate bioscientific knowledge[15]. The discovery of the X-ray (Röntgen, 1895) qualitatively transformed medical practice by technologically guiding the medical gaze into the inner body. Similarly, the X-ray inspired other imaging techniques, including X-ray computed tomography, whose introduction in 1970 sparked the definitive transition, as we have mentioned before, between analogical and digital medical images. That the medical gaze overcomes the challenge of crossing the opacities and resistances of the human body - that corporal mass in which "the mystery of the origins of life and disease" hides - culminates in the contemporary project of reorganizing the space of pathological phenomena, producing a horizon of techno-images whose interpretation is not exclusively restricted to scientific confines (rather, it is open to any actor who views it *via*, for example, the internet or other mass-produced material such as science magazines – of this, more later).

[15] "In the last decade of the nineteenth century an almost magical invention - a chance discovery, in fact-stole - the limelight from the various photographic techniques of imaging the body's interior. With 'X-rays', as their discoverer Wilhelm Konrad Röntgen called them, it would henceforth be possible to peer inside any living human body without so much as touching it, let alone opening it up for inspection" (Ewing, 1996, p. 9).

Another point made here is that biomedical images are not mere representations of pre-existent objects but "operative images" - representations that are, essentially, technologies that can virtually transform corporeal tissues, organs, sections on computer screens. This is what Weber (1996) termed the "differential specificity" of the medium, to explain not the shift from the concrete physical body to a new medium, but rather *the transformation of the body's very material possibilities*. Concurrently, the medical gaze overcomes conventional self-identification approaches (responding to the inveterate question of the mimesis), because medical techno-images are no longer only perfect copies of the body but are technologically sophisticated (and manipulable) representations of it (Thacker, 2000; Waldby, 2000; Cubitt, 1996; Dubbeld, 2006).

In sum, the technical magnification of the gaze's scope not only redefines the old European substantialism, but inspires philosophical reflection and intense controversy about the very essence of life. Once the processes explicitly associated with life have been subsumed by an autonomous metabolic system that regulates energy and molecular production - that is to say, once scientists assume that life can be interpreted from a biochemical paradigm based on essentially genetic principles - the conceptual boundaries of life become flexible and porous, and historical reflection on the human condition can move more freely towards a new technology of the human.

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