# Visualizing the World. Epistemic Strategies in the History of Scientific Illustrations

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*Published in:*
Ideas in History. The journal of the Nordic Society of the History of Ideas

2012

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ISBN 978 87 635 3936 4

9 788763 539364

www.mtp.dk

MUSEUM TUSCULANUM PRESS

# Ideas in History

Journal of the Nordic Society for the History of Ideas

VOLUME 5

NO. 1–2 • 2010/11

# Visualising the World

## Epistemic Strategies in the History of Scientific Illustrations

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### Abstract

A look into the history of sciences shows that pictures and illustrations had a decisive role for the sciences progressive success and rising social status since early modern times. Illustrations transformed the unknown to graspable facts. Without the pictures, the new discovered continents, the blood circulatory system and the body's muscles remained theoretical proclamations. Scientific discoveries became visible and communicated to a wider audience via their illustrations.

Scientific illustrations and maps were intertwined with an epistemic ambition to unveil the true natural order. During the seventeenth century, the concept of objectivity was interpreted as a quest for revealing nature's ideal order – a task only feasible for the brilliant artist to accomplish. This epistemic ambition concurred with the belief that only one true ontological order existed. Fidelity to nature as the ruling standard for objectivity was succeeded by other standards of objectivity, such as mechanical objectivity and trained judgement (Daston and Galison 2007). The modern concept of objectivity, equated with objectivity with impartiality and elimination of the scientist's subjective bias, is the most well-known example. However, this has not been the only epistemic virtue to service the sciences.

The presence and radical expansion of computational pictures in the sciences as well in everyday life raises the question of new senses of objectivity. This is dependent on that the new objects are inseparable from the technologies that produce them. Still, one must consider claims that the 'nowhere view' has a renewed relevance due to technologies that constitute and are inseparable from the new digitalised maps and atlas. The ideal of objectivity is maintained, but attributed to automatically produced degrees of certainty. Informatics has displaced the human judgement as the most reliable source for objectivity. Evaluation is built into these new maps. In physics and chemistry, the processed pictures intend to be contributions to an ongoing engineer-inspired discussion about how to shape nature. However, the traveller does not engineer but designs her own map in advance; he or she mixes Google earth features with the personal arrangements. Still, despite the

personal design, the hybrid map is regarded as objective knowledge. For both the scientists and the laymen, the modernist objective virtues of detachment, impartiality and disinterestedness have been further idealised by the informatic structures implemented by contemporary technological machineries.

**Introduction**

The history of scientific illustrations could be written as a parallel to the history of science. Representations of different kinds permeated the scientific works from the early modern era. The scientific world view was spread and established by pictorial maps and illustrations. Expanded geographical knowledge during the sixteenth century made the Ptolemaic world map obsolete. New world maps were produced that included the continents of North and South America (for example, in Martin Waldseemüller's *Universalis Cosmographia* from 1507).[1] Further, the scientifically-inspired maps illustrated new scientific discoveries – geological layers, magnetic declination and population density. These discoveries were real facts. Without the maps, however, such discoveries would have been purely theoretical descriptions of the world, invisible to the observer's everyday range of senses. The power of maps and pictures helped science to acquire its prestigious and superior position in modern Western society.

Until the late 1970s, historians, sociologist and art historians paid little attention to visual images. This has changed rapidly over the last decades. The former view that scientific visualisation was mainly about representing objective data acquired by pure cognition has been replaced by an expansive and intensified attention to visual images, often as a part of more general interest in the details of scientific practices. However, this interest is mainly represented in art history and science and technology studies. In general questions about the epistemological status of the computational pictures have been absent; this is in favour of more discursive analysis of practices, organisation and power relations. Also in the history of science, analysis of visualisation has been a small subgenre. The text has by tradition been the prime source for the historian.

Science and technology studies have been groundbreaking and pioneering for visuality in the sciences (Lynch and Woolgar 1990). Their results

1 A basic reproduction of this atlas may be seen at http://www.loc.gov/exhibits/earlyamericas/maps/



have raised another challenge, namely how to delimit what the topic includes. Michael Lynch has pointed out that studies of visualisation in the sciences are in part, but only in part 'about maps, diagrams, graphs, photographs and other pictorial documents produced as evidence in laboratory research and published as illustrations in scientific texts' (in Pauwels 2006: 27). The description correctly stresses that studies of visualisation are 'deeply integrated with a nexus of activities that include observation, measurement, description, analysis and demonstration' (Pauwels 2006). The focus in this definition is visualisation as intertwined with observational and experimental concrete practices of sciences.

Visualisation is a wide phenomenon and difficult to grasp; it can be understood as a complex assemblage of virtual, material and symbolic elements, it is an important tool for representing virtual, imagined and possibly existent entities (Jones and Galison 1998).

A reason why maps and illustrations have been a constant companion to science is the functional flexibility of encompassing a wide range of phenomena that are not visual or not even existent according to naturalistic criteria, *yet still* represent realistic and symbolic qualities. The genre of symbolic maps aims at making qualities in the non-real world visible and accountable by representing them. Old religious maps had the intention of communicating to the observer a religious and doctrinal worldview. The famous Hotan Buddhist universe map, Nansenbushu Bankoku Shoka (c. 1710), is void of man's presence, but tells the informed observer that the known universe is only one among millions of others (Cosgrave in Akerman 2007: 75). The depicted religious universes also communicated the symbolic message that infinite space existed for man's soul.

My focus will be on how maps exemplify different epistemic strategies; this is 'epistemic' in the sense of articulating and transforming knowledge to a justified body of beliefs, and by using the available and suitable means of producing the image. I will here limit the task to look at two epistemic strategies expressed with special distinctness in the history of mapmaking. These sought to, first, establish and spread the truth of new material or symbolic realities and secondly, to illustrate shifting epistemic virtues that had interfered in illustrating the envisioned object. My claim is that these two epistemic historical routes are embodied in the history of maps. The illustrations of reality and the shifting epistemic regulative ideal of how the reference to reality should be worked out are deeply intertwined. The focus is epistemic, meaning that dimensions of cartography in the service of exerting political power; in other words, social and political discourses in maps are left out.[2]

Maps have wider relevance for understanding of how visuality as a part in the epistemic process has functioned in the history of science. The visual illustration contributes to make an aspect of reality, symbolic or material to a certified assessment that can be accepted or rejected, or neutrally embedded in an existing practice.

Examples of the first epistemic route are the geographical maps. They are representations of physical facts that are not directly observable in the natural scale, but become available for the observer by a visual representation (Akerman 2007; Black 2003; Livingstone 2003). The produced images make an otherwise invisible world graspable for both the scientific community and the laymen.

The second epistemic route epitomised in the history of maps is the historically shifting ideals of epistemic virtues. Maps are situated in historically shifting regulative ideals, frameworks that provides the mapmakers with the available standards. Regardless of the shifting epistemic standards, the goal is a faithful representation of nature – at best intuitively reliable for an observer.

Often the active image making is attributed the spread of computational image making and the Internet, with its interactive visuality. No one would object that with computational image making, the options for a subjective projection have expanded far beyond the early modern period. Nevertheless, I will try to show that maps are illuminative examples for regulative ideals of objectivity for the sciences in general. Considered as an epistemic representation, they exemplify different regulative ideals for representing objective reality.

Important features of both these intertwined epistemic routes – the spread of new realities and the shifting epistemic virtues that had interfered in illustrating the envisioned object – is that they are inherent in the genre of images. These 'routes' give access to whatever the addressed ob-

2 Harley and Laxton (2001) approach to the cartographic is to reveal and deconstruct the history of mapmaking. Hence, in his book historicism and relativism tend to go hand in hand, which results in a deconstructive analysis.



jective is. They are what the philosopher Nelson Goodman called 'ways of world making' (Goodman 1978). The pictures are not only mirroring, but construct the world (Mitchell 2005: xv).

Despite these imaginary qualities, a common feature stands out in the history of scientific illustrations. Epistemic strategies had the ambition to unveil the true natural order. What has previously counted as the most reliable epistemic strategy to unveil nature and find the true natural order has been subject to change. The concept of objectivity has a history that the maps distinctly illuminate.

## Visual Capacities: The Spread of New Realities

A traditional function of scientific illustrations is to serve as a creator of new spaces and new realities by visualising the unknown and unseen. Google Earth is certainly a new tool, but it expands and improves this well-known function of maps. Since the early modern period, world maps, as well as local maps, relied on a cartographic tradition that combined the instructive task and the viewer's ambition to orient herself visually in the chosen space, be it for a pilgrimage or holiday trip. In the case of traditional historical maps, this feature was strikingly apparent; towns, seas, coastlines, and roads are represented pictorially. The cartographer's artistic skills were the means of providing this visual pleasure. However, a component of this pleasure was the presence or evidence of human existence. Early modern world maps, accurate according to contemporary scientific standards, invited observers to apply their intentions, matched by identification symbols, as the Miller (c. 1519) atlas exemplifies.[3]

The Miller atlas offered a bird's eye view of the grandeur of the Portuguese Empire, with its commercial trading ports in Malaysia in the Far East, and Mogadishu on the East African coast. The atlas had splendid illustrations of Portuguese castle constructions and Portuguese ships all over the world seas – pictures that defined the superiority of Portugal. An atlas produced by a skilled artist engaged a spectator's imagination; it made the empire visually and physically within grasp. This was achieved by the distinct outlines and artistic quality, but within a certain regulative framework.

3 A basic reproduction of this atlas may be seen at http://www.heritage-images.com/Preview/PreviewPage.aspx?id=1156596&pricing=true&licenseType=RM

The atlas exemplified how a naturalistic framework created symbolic space that facilitated the imaginative power of what it meant to be Portuguese in the sixteenth century (Black 2003).

When Louis XIV commissioned the Venetian spherographer, Vincenzo Coronelli, to produce the biggest and most impressive globes ever made – situated in Marly but intended for the Mirror Gallery in Versailles 1683 – the King expressed his power as the ruler not only of France, but also as a global emperor. The two globes each measured about four meters in diameter. For scientific skilled observers, the globes were accurate scientific representations, according to prevalent epistemic standards. Yet, the globes also represented the King's ambitions. The huge scale was intended to encourage belief in the king's supreme power. A pure imaginative world in one moment could also be a future factual world (Dillon 2007: 319).[4]

During the nineteenth century, 'social process' emerged as a new scientific conceptual category. Social surveys and statistical analysis during the nineteenth century encouraged to apply graphic for making otherwise invisible phenomena graspable in the form of maps. When maps were used to illustrate expanded scientific statistical fields related to morality, areas with high criminal rates were coloured black and safe areas appeared in light colours. André-Michel Guerry (1802–66) was a pioneer in making comprehensive map overviews of the moral state of France in the 1860s (Friendly and Palsky in Akerman 2007: 243).[5] His moral maps illuminate an important and repercussive phenomenon, the maps are not cartes blanches; they are structured according to a regulative epistemic standard that in this case coincides with the common standard. If areas with high rates of crime had been coloured white, the usual cultural association between dark colours and miserable lives would have been blurred, causing confusion.

The nineteenth century represented the peak of innovative, user-friendly illustrations in the field of science. Illustrative techniques adhered to the style of popular illustrations by complementing graphic innovations with visual forms used in newspapers and weekly magazines (Dillon in Akerman 2007: 299ff.). These maps illustrated that the intended function, be to

4 The Coronelli globes may be viewed at http://expositions.bnf.fr/globes/bornes/itz/27/01.htm

5 A basic reproduction of this map may be seen at http://ookaboo.com/o/pictures/noindex/picture.original/11852839/A_picture_of_AndreMichel_Guerry



enhance the emperor's power or to introduce new scientific perspectives (such as the category of the social) still did not represent the detached and impartial view from nowhere – a view that later would take over the expansion of the natural and social sciences. This expansion was accompanied by more abstract formal illustrative modes that underlined the scientist as an expert, with knowledge inaccessible to the educated general public. A new epistemic standard emerged. This still aimed at fidelity to nature, but by other means.

In this context, scientific maps and more popular, illustrated maps diverged into two different genres. Popular maps remained close to the traditional genre of early modern maps as realistic pieces close to the artistic works. These maps continued to invite the observer to project her expectations and knowledge into the maps. This was as a way of familiarising herself with unknown territory in advance. Scientific maps acquired a more abstract, statistical look. The intention was to communicate scientific data, conceived as an external non-personal object. Subjectivity was defined in a Kantian sense – a personal psychological sentiment, and in opposition to objective scientific knowledge, devoid of the subjective self. The scientifically-minded cartographer did her very best to remove all traces from the subjective personalised bias (Daston and Galison 2007: 27ff.; Friendly and Palsky 2007: 228ff.).

### Expanded Visual Capacities: Personal Design and Time Travelling

During the nineteenth and twentieth century, the scientific maps were recast to purify representations, devoid of intervention by the scientific ego. Subjective variability had to be suppressed, reflecting fear of distortion of the natural subject (Daston and Galison 2007: 369ff.).

With satellite images, naturalised global pictures have regained the anthropocentric perspective characterising pre-modern world maps. Google Earth stands as a prime example for this striking feature; twenty first century map development illustrates how the visual has reached an unprecedented innovative rate by the computational techniques. In Google Earth, the screen opens with a view of the globe, produced by naturalistic satellite photos. Within a few seconds, however, a manmade cultural world of landscapes, cities, roads and houses come into view, we follow-up by zooming in, focusing and selecting our personal design.

Nowadays, many of us start a trip by logging onto the computer, typing in the departure address and the required destination, and requesting a route. After a few seconds, a detailed route description appears on the screen together with a two-dimensional map. If we use Google Earth, a three-dimensional view of the required destination appears. My use of a computer map search illustrates a new phenomenon, namely, that in the digitalised map world, a personal subjective travel advice function can be added to a standardised map available to the public.

The standard function of maps is to help the user to perceive the places visually in advance. Now this function has expanded; a well-known function in Google Earth is to fly to an unfamiliar place, and via its images, familiarise us with it in advance. We do not only know the names of the streets, the blocks, the metro lines; we can fly to places and inform ourselves about a hotel's location, and look at the rooms by a virtual tour. Google Earth has managed to map entire cities, road networks, and towns to details as minute as biking lanes by free access to the program Map Maker. This enables people to add their local knowledge directly into a map. Before the added information is available, its accuracy is checked and coordinated into the latitude and longitude coordinates. Young people all over the world get familiar with this program in science classes; Google Earth is often used as an interactive inquiry-based tool for learning geography and exploring the Earth.[6]

Such hybrid maps add realism to naturalism, guaranteed by scientific data. The flow of digital informatics provided by Map Maker changes the content of maps constantly. Important for the argument is that even the personalised map claims objectivity. Regardless of the user, maps are expected to be realistic. A map that does not give a correct representation of the required phenomenon be it a body, a location or a metro map is not a map, but a piece of art.

It is worth noting that such developments allow another human dream to come true, namely time travelling. Among the latest added material to Google Earth are historical maps, that makes inverted time travelling easy. We can travel from the present into the past or from the past into the present, depending on our purpose. Historical maps can be exactly covered

6 In the US several educational sites teaches how to use Google Earth in earth science education. See http://serc.carleton.edu/sp/library/google_earth/how.html and http://www.eastchester.k12.ny.us/schools/hs/teachers/fermann/documents/GEforESmanual.pdf



by a visual image from a Google Earth map.[7] For archaeologists, historians, and cultural geographers this option opens up areas of new knowledge. Science fiction has to cede space for a new genre where past and present merges with minute scientific accuracy.

One might ask how to make sense of this mix of historical and current maps. Are we challenged by these new computational techniques to rethink notions of realism? Will reality and history be another fictional digitalised game that helps to form our identity, as online games might do (Castronova 2007)? We can all agree that digitalised services have encouraged people to use maps more often and expanded cartographic literacy, but what this means for our ontological and epistemological awareness is a wide open question.

Intellectual historians and historians of science have only recently begun to address questions of whether computational techniques challenge us to rethink notions of realism and imagination; how are scientific standards affected by the computational image processes? Commentators from art history and visual studies have claimed that our immersion in computational images represents a 'visual turn'. It has also been suggested that parts of the sciences have reached 'the end of representation' and that a new visual literacy is needed as a complement to linguistic literacy (Elkins 2008a, 2008b). Arguments can be made for and against a visual turn in the sciences and hence whether it implies changing epistemic standards. Philosophers and historians have in general shown limited attention to the epistemic and ontological aspects of the computational visualisation processes, such as those discussed here, even if there are some good exceptions of historically-oriented philosophers who try to identify characteristic institutional and methodological changes in the past half-century. This is to ask whether we should interpret these changes as a major, epoch-making shift in the sciences (Carrier and Nordmann 2011).

## Epistemic Visual Objectivity in Flux: From Representation to Presentation

Objectivity is a notorious blurry concept as it can refer to a whole range of statements: objective truth of a scientific claim, objective procedures to guarantee a valid result, and the professional attitude that characterises the

7 See, for example, http://www.davidrumsey.com/view/google-earth-browser#scandinavia-1794

professional scientist. One of the general virtues initiated by the Kuhnian discussion, further enhanced in history and science studies, was the his- toricising of philosophical concepts that had been assumed to be universal and monolithic. Among the concepts that acquired a history was objectivity (Daston 1992; Daston and Galison 2007; Porter 1995). Even if the topic had for long been a favourite among philosophers, their focus has been on the existence and legitimacy of objectivity, how to get a proper representation of reality and not on changing historical senses (Nagel 1986; Popper 1972; Quine 1953). The definition of philosophical realism or objectivism – the view that there is a reality or ontological realm of objects and facts that exists independent of the mind – fits indeed very well into the new compu- tational visual turn in which the observer has been replaced by a doer. The ontological status of the object is taken for granted and connected to the potent ideal of objectivity. Scientific process is nonetheless heterogeneous, making it misleading to talk about visuality in the sciences as a monolithic task. For example, in the medical sciences, molecular chemistry, astronomy and parts of physics the primary goal is to make a faithful representation of nature. The computer is the powerful device for achieving this goal. The clicks and key strikes that cut and rotate, colour that modify or change the phenomena aims at getting the amount of rough data into compre- hensible realistic representations. Such manipulations strive for accurate representations, not falsifications. This sort of image-making can be kept apart from visual technics in nanotechnology in which objects are made and come into existence by the visual presentation in which the entity can be processed in different ways. In the nanosciences, the quest for a natural- istic visual representation is invalid, as the fabricated material is a complete artefact (Knorr-Cetina 1999: 79–110). One can object to this division built on realistic criteria by claiming that common digital data structures are constitutive for the sciences, not the relation to reality.

In their book *Objectivity*, Lorraine Daston and Peter Galison present a history of scientific objectivity since the seventeenth century (Daston and Galison 2007). The aspiration to depict reality in a reliable way has been a constant challenge for scientists from the early modern era to the present. Before photography, non-realistic tropes such as allegory, metaphor and synecdoche were frequently used as a way of revealing the true nature of nature, an approach the history of maps illustrates. Scientists considered



themselves void of the necessary idealistic qualities and employed artists to do the right depiction, according to accepted standards.

Andre Vesalius's pioneering work *De Humani corporis fabrica libri septem* exemplifies this epistemic virtue, 'truth to nature' (Vesalius 1543). It contained detailed drawings of the human body, the skeleton, the muscles and the brain. Depicting the true essence of nature required a genius that could see pure essence beyond the surface variability of nature. The common human eye was too imperfect to reveal the truths of nature. Only the artistic genius had the skill to depict the ideal perfect body, a quality that the researcher only owned as an exception (Daston 1994; Daston and Galison 2007).

Vesalius engaged a professional artist, Jan Stephen van Calcar, who also mastered wood engraving in order to assure that the bodies were depicted with highest possible perfection, true to the natural order. A famous quotation from Francis Bacon epitomises this attitude about the truth claims in scientific illustrations: 'Seeing that the nature of things betrays itself more readily under the vexations of art than its natural freedom' (Weinberger and Bacon 1989: 63)

In the beginning of the early nineteenth century, leading naturalists began to worry that the quest for natural regularities would be overwhelmed by scientific attention to nature's extremes. The creative artist was no longer considered to be the right talent to depict the truths of nature. The concept of objectivity changed to guarantee unobstruction from subjective values. The epistemic virtue 'mechanical objectivity' became the new standard. The aestheticisation of the natural creation was regarded as an aberration which blocked true understanding of transcendent knowledge of nature's order. The artist was replaced by the expert; Leonardo da Vinci was replaced by Robert Koch. In both cases, pictures were important knowledge sources. Nonetheless, normative rules for truth representation changed drastically. Leonardo da Vinci's pictures represented the view that essential knowledge required intervention from the genius with his creative reason intervened; Koch viewed the instrumental eye as the prime reporter of truth. A vague photo was preferred to distinct drawing (Daston and Galison 2007: 166–67).

In addition to all this, Western maps changed in appearance. This was in their capacity as the forefront of new standards of objectivity. Until the seventeenth century, maps in Europe were anthropomorphous, depicting the natural and the cultural world from a concrete human point of view. Edmund Halley's world map from 1702 illustrates how the pictorial ideal had changed to an abstract scientific style which used scientific symbols based on mathematics, void of the anthropomorphic perspective striving to fulfil the new mechanical objectivity. The early modern sea monster had been substituted by a rational, scientifically calculated sign (Akerman 2007: 100f.).

The third and last epistemic virtue in Daston's and Galison's book is named 'trained judgement.' An expert is doing the interpretation that aims at discerning patterns, not types. Long experience and unconscious intuition are prominent features. A well-known example for the medical practice of the 'trained judgement' is the X-ray pictures (Jülich 2002).

All these three epistemic virtues shared a common goal: namely, faithful *representation* of nature. How durable and useful will these epistemic virtues be in the present techno-scientific era? The mix of different temporalities and diverse genres in new computational pictures invokes anew the question about truth and objectivity. A distinction to keep in mind is that image producers sometimes sacrifice naturalism for the realism. The films of Swedish photographer Lennart Nilsson are consciously mixes of artificial animations with photos from the body's inner parts. These are produced in order to get better realistic images, easier to interpret than the sometimes blurry and indistinct pictures microscopes can offer.

The legitimacy of science since the seventeenth century has been based on truth-seeking practices. A pertinent question is if the practices of computational visualisation indiscernibly displace the border between representation and intervention in ways that changes the established scientific standards.

Even if the imagination intrudes into the space of the cognitive via the *wide range computational tools such as colouring, sizing and rotation, the overarching aim in the sciences is still to represent nature in a faithful way. A changing ontology in the scientific vision –being able to discover and* document different aspects of reality – does not necessarily imply different epistemic normative ideals. The lure of the visual is maybe to experience the visual more vividly and strikingly than it actually is. Another challenge is connected to the vivacity of the visual. The subatomic data that makes



up the picture represent a mathematical equivalence – that visual tools are 'dressed' into a physical shape.[8] Anne Beaulieu, a Canadian-Dutch sociologist, has called attention to the fact that the computerisation of images leads to 'a devaluation of visualisation as the mathematical manipulation stipulates the binary format' (Beaulieu 2001). For the biosciences, the new modes of visualisation as cognitive aid account for consideration of the relation between referent and the representation.

The case is different in the nanosciences. Gaining knowledge is equivalent to producing new materials and presenting them on the computer screen. Traditional dichotomies of nature-culture, representing-intervening and science-technology are placed in flux. New, artificial materials are made by intervening in nature with high technological methods. The representation – or presentation 'as such' – is entangled with the computational processed intervention, as the material does not exist in nature. The idea of representation presupposes an idea of distance between the object and its representation. In technoscience the representation ceases to be a representation (Hacking 1983; Nordmann 2010).

The emergence of technoscience does not imply that the traditional epistemic virtues have become obsolete; 'epistemic virtues' are rather accomplished in a different way based on different kinds of relationships with the technologies at hand. These accumulate and exist side by side as Daston and Galison suggest: truth to nature, mechanical objectivity and trained judgement are still valid (Daston and Galison 2007: 363). In clinical biomedicine, the epistemic virtue of doing an objective body representation is crucial. Even if the patient's body is matched with a computerised atlas, and the objective judgement is processed by the computer during examinations, the machine's verdict is not the last one. A current practice in the medical sciences – in case of the circumstances – is to do a post mortem examination, comparing the computational generated body images with the dead, but non-virtual, body tissues. This may suggest that institutional practices will continue to maintain simultaneously *the established epistemic virtues of mechanical objectivity and trained judgement. One could add that a new 'digital objectivity'* is under construction. Nonetheless, this is

8 One of the objections against the British physicist Roger Penrose's 'cycle theory' of the universe is that the mathematical dates are not matched with physical evidence. See Penrose (2010).

still a thin epistemic concept constructed from studies on brain images in the neuroscience (Beaulieu 2001).[9]

The examples from biomedical practices make it seem dubious to collapse the distinction between representative and non-representative images. Even if the image is made by transforming collected non visual subatomic data, the ultimate normative reference is the body, dead or alive. The scientific aim is to uphold a representational truth – effective also in the computational world. One should also keep in mind the difference between a metaphysical standpoint that rejects the possibility of the ultimate representational truth with the quite trivial opinion that a certain phenomenon is an artefact of instrumentation (Pauwels 2006: 34).

In a historical perspective, the ontological dimension has been taken for granted in epistemology; ontology mattered, be it religious or naturalistic. Such ontological concern is absent in the nanoworld; it is not viewed as a pertinent problem. One might consider whether this condition calls for a revitalised hermeneutics of science – one which provides with tools to reflect on the dialectics between epistemic construction of reality and our ontological predicament; subjectivity may be the precondition for knowledge. The neo-Kantian strategy as it was developed by Henrich Hertz and Wittgenstein emphasised that the agreement between the object and its representations took place within a framework of inter-subjective quantitative mathematics and the limits of language. The scientific period from the late nineteenth century and onwards upheld an image of pictures and maps as presumably true representations of the subject; in other words, that an agreement between mind and nature was epistemologically valid. A question is whether current theoretical resources in human and social sciences can rise to the challenge of analysing and understanding how these new computational techniques mediate between the entities, objects and processes that are visualised.

In the present techno-scientific era, several epistemological positions are in flux; we can pose questions, if not answers. If earlier periods produced scientific era with truth telling as the primary scholarly task, the digitalised

9 Beaulieu (2001) expands her subjects, neuroscience and brain mapping to a discussion of whether a new kind of objectivity distinguish the present digitalised informatics based science. She suggests the concept 'digital objectivity' which is marked by the observers diminishing role in the digitalised scientific work. The automatic evaluation is built into the processes.



life-world offers new tools not only for exploring the world by zooming, rotating, colouring and flying through, but also to alter and produce new materials and fictional worlds. In the history of sciences, the imaginative capacity to produce visual images has been a constant companion to disclose hidden worlds. This has been from religious kingdoms to inner parts of the body. The new techno-sciences refurbish the world by creating new material components, be they material as *grafén*, cloned animals or bodily inner organs. Immersed as we are by the digitalised visual world, we might take objectivity for granted; or, being ontologically indifferent, we may forget that coming close to reality requires artful reconstruction. Over the centuries, the scientific imagination and its results have been artfully materialised in visual representations. This is key to the functioning of the sciences; visualisation is the most efficient tool for producing, exploring, unveiling and making new worlds visible.

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