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I.

Landscapes need spectators. Even when it is not pictured by a painter or photographer, the landscape is a picture of space that is seen from some distance and that is framed by the position and visual reach of the viewer. The space that is seen has not been entered though it is definitely a space that one might enter.

Astrid Schwarz shows in her contribution to this volume what happens if one changes the angle and views a landscape from above by means of aerial photography. When we look horizontally into and beyond the scene, we see a lake in its natural setting. Here, the landscape organizes an interplay of multiple features and its aesthetic unity permits the viewer to question these relations. Seen from above, however, the lake becomes absorbed into a two-dimensional aerial map and reduced to a detail of a whole. Here the new media technology of aerial photography transforms the landscape into a map and turns the picture of a space into a flat arrangement of signs.

One might also consider another transformation by another media technology. It constructs landscapes that transform the spectator into an actor. Here the landscape ceases to be the picture of a scene but becomes identified with a space for doing and building. It is no longer an object of beauty or knowledge that is beheld by artists and geographers. The scene becomes a terrain that needs to be negotiated as one passes through it. Astrid Schwarz describes the move from landscape to map as a discontinuous change within the continuous movement of seeking higher and higher vantage points. Similarly, the profound transformation from spectator to actor, from pictured space to negotiated terrain results from a continuous development that started with attempts to render interior spaces visible by rendering them as landscapes. However, as cavernous spaces yield landscape views, the landscape becomes a cavernous space that beckons to be entered and explored. Indeed, one might trace this transition quite literally from techniques for the representation of the interior landscapes of caves to techniques of rendering representations as interactive caves.

In 1654, Matthäus Merian produced what is probably the first published view of the interior of a cave.[1] It appeared as part of a *Topographia* which catalogued cha-

1 Stephan Kempe et al.: Die beiden Merian-Texte von 1650 und 1654 zur Baumannshöhle und die dazugehörigen Abbildungen. In: *Die Höhle* 52(2), 2001, pp. 33–45; Stephan Kempe: The Baumann's

racteristic views of «the most distinguished cities, castles, and other places and sites» in a politically defined region of Northern Germany.[2] Merian's prints typically provide scenes that situate the selected site at the horizon and within its natural setting, they are therefore paradigmatic for the visual conception of landscape as something that is seen from a vantage point that is removed just enough to show an entire scene of a site in its surroundings.[3] For the depiction of the cave, a large hall is selected that affords the proper distance to a scene, and the scene itself resembles a somewhat amorphous mountain range with a valley stretching through. The vantage point of the spectator is dramatized by two figures in the foreground who illuminate the scene with their torches and indicate by their small size that the stone formations in the cave are overtowering them.

Fig. 1: From the cave to its representation: Merian's view of the Baumannshöhle

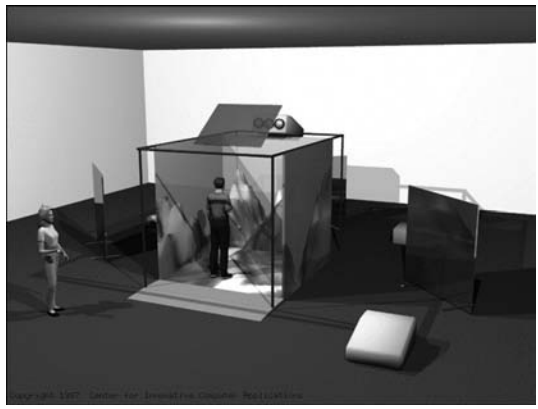

Fig. 2: From the representations into the CAVE (Cave Automatic Virtual Environment)

Merian's cave is a subterranean version of the world experienced above with its landscapes, ground and horizon and breathtaking views – and significantly, it does not have a ceiling. With the publication of this print coincided the beginning of

Cave at Rübeland/Harz, Germany, one of the Caves Noted in Early Science History for its Cave Bear and Cave Hyena Bone Deposits. In: *Scientific Annals, School of Geology, Aristotle University of Thessaloniki (AUTH)* 98 (Special Volume), 2006, pp. 213–220.

2 Matthaeus Merian (Ed.): *Topographia und Eigentliche Beschreibung der Vornembsten Stäte, Schlösser auch anderer Plätze und Örter in denen Herzogthümern Braunschweig und Lüneburg, und denen dazu gehörenden Grafschafften und Landen*. Frankfurt 1654, pp. 31–33, 63.

3 Albrecht Koschorke: *Die Geschichte des Horizonts.* Frankfurt/M. 1990; Chunglin Kwa: Painting and Photographing Landscapes: Pictorial Conventions and Gestalts. In: *Configurations* 16, 2008, pp. 57–75.

tourism in caves, and ever since the mid 17th-century guided tours would lead visitors to vantage points from which to behold these subterranean landscapes. And also since these times, the spectacular scenery in the great cavernous halls served as a stage quite literally for musical and theatrical events. The interior of the cave thus becomes staged as a landscape, and the landscape as scenery and stage serves to organize the tourist's experience of the cave: The geological history of the Earth represents itself by way of a bizarre cast of stalagmitic characters that animate the scene (Fig. 1 & 2).

Leaping forward several hundred years to the end of the twentieth century, one encounters an inversion of this technique. In universities and science museums alike, the cave appears as a representational device and instrument of inquiry. By stepping into this artificial cave one steps, for example, into the interior of a cell. Equipped with a joy-stick for navigation, the investigators are surrounded on four walls, ceiling, and possibly even the floor by the various kind of molecular machinery. This is to enable them to see molecules as molecules «see» each other, and thus to experience viscerally the forces that draw molecules together or hold them apart. By becoming actors within their own simulations, they can feel the effects of their own interventions and acquire intimacy with the actions of the protein they wish to inject or with the tumor they are about to surgically remove.[4] Here, representational capabilities are extended to create an environment in which the investigators are no longer spectators but explorers of the cave. Instead of watching the scene from a distance, they act on and in the scene, and accordingly they do not see a landscape but find themselves in the midst of the action.

Between the cave as a landscape and representation of a space and the representation that constitutes a cavernous space of exploration, numerous media techniques explore a middle ground, namely that of inner space travel which leads the explorers to sublime views of interior landscapes and casts them also as actors in this scenery. There are cinematic adventures in subterranean worlds or in the inner space of the human body, such as *Journey to the Center of the Earth* or *Fantastic Voyage*. There are also video games that afford players the experience of being immersed in a half-familiar scenery as they navigate their fighter jets through narrow canyons. There are finally the nanotechnological surface-scapes created by scanning probe microscopy and its associated software that, often enough, is adapted from the topographic visualization tools of geographers.[5] These surface-scapes open a

4 See for example, Inge Hinterwaldner: ‹Actions of Interest› in Surgical Simulators. In: Bruno Latour et al. (Eds.): *Making things public. Atmospheres of Democracy*. Cambridge MA 2005, pp. 338-341; Colin Milburn: Atoms and Avatars: Virtual Worlds as Massively-Multiplayer Laboratories. In: *Spontaneous Generations: A Journal for the History and Philosophy of Science* 2:1, 2008, on the web at jps.library.utoronto.ca/index.php/SpontaneousGenerations/article/viewArticle/4895 (22.12.09); Inge Hinterwaldner et al. (Eds.): *Topologien der Bilder*. München 2008.

5 Jochen Hennig: *Bildpraxis: Visuelle Strategien in der frühen Nanotechnologie*. Bielefeld 2010 (forthcoming).

space of deliberate technical action that did not exist prior to their visualization. They show that, indeed, there is plenty of room at the molecular level and that this space is largely uninhabited as yet. Topographically, these molecular landscapes are quite familiar, only the colors are off as they might be on another planet. And just like those on Mars they invite *homo faber* to come in and start shaping the world atom by atom.[6]

When lakes become absorbed into the totality of a two-dimensional map and when the observers of nature become actors in their own plays, what has changed is how researchers behold their objects. In order to appreciate this change, it does not matter much whether a new manner of beholding research objects results from the changed media dispositif of new technologies,[7] or whether new technologies and novel uses of old technologies answer to a change of epistemic standards and expectations. What does matter is the collapse of distance that results from a gradual improvement of representational techniques and that signals the discontinuous end of science as a representational practice which aims for a theoretical description of the world.

«Collapse of distance» refers to a change in the manner of beholding an object or of being related to the object, that is, of the dispositif that orients mind and body to the world. Since our orientation towards the world includes sensory as well cognitive modalities, an inquiry into the collapse of distance necessarily involves aesthetics and epistemology simultaneously. And this is where «landscape» came in – it refers to an aesthetic unity that arises with a certain manner of beholding sites and their surroundings, but it also refers to the epistemology of the scientific observer as spectator of a scene. The distance between the observer and what is observed resides in the fact that a landscape is the picture of a space in which the observer is absent. As soon as we move into the immersive, video-gaming space of the cave, its representational devices no longer require distance but serve to produce immediacy: The cave is not a scene to be watched from some distance, but a stage to be entered and explored.

Another simultaneously aesthetic and epistemological category is «experiment.» If one conceives of experiments primarily as means to assess theories and hypotheses, this involves a particular cognitive and sensory orientation which once again casts researchers as distant observers of a scene. After setting the stage and building an experimental system, these researchers step back in order to convince themselves that they have nothing to do with what happens next: The experiment

6 For an account of nanotechnological inner space travel and its relation to the slogan «Shaping the World Atom by Atom» see: Alfred Nordmann: Nanotechnology's Worldview: New Space for Old Cosmologies. In: *IEEE Technology and Society Magazine* 23:4, 2004, pp. 48–54; also Astrid E. Schwarz: Shrinking the Ecological Footprint with Nanotechnoscience? In: Davis Baird et al. (Eds.): *Discovering the Nanoscale*. Amsterdam 2005, pp. 203–208.

7 See for example, Jean-Louis Baudry: The Apparatus: Metapsychological Approaches to the Impression of Reality in Cinema. In: Philip Rosen (Ed.): *Narrative, Apparatus, Ideology: A Film Theory Reader*. New York 1986.

begins when things simply unfold and when some spontaneous effect can be observed on the stage that was meticulously constructed by the researchers. But one can conceive of experiments differently, namely in terms of dramatic events that harbor surprise and the challenge to control it. In this regard, the researchers do not observe the experiment from a safe distance but are deeply implicated in its performance. They participate in the experiment's dynamics of suspense and revelation by demonstrating to their audience what they have learned to do and what effect they can achieve.[8]

A third category appears to be primarily epistemological on first sight. However, the «model» is not just a tool for mediating between theory and reality but also a way of relating to the world and of beholding the objects, phenomena, and processes in the world.[9] Here it is the advent of animal models and simulation modelling that signals a collapse of distance where the model no longer stands at a representational distance to reality but where it becomes a substitute reality by virtue of participation and similarity. It is here that the opposition of pictorial representation vs. immersion and participation in a cave-like situation can be discussed most generally, and where the collapse of distance serves most clearly to distinguish not only two ways of beholding but two ways of conducting research, one scientific, the other technoscientific. But this requires us to step back for a moment from landscapes and caves, different conceptions of experimentation and modelling, and to consider more generally scientific and technoscientific ways of conducting research.

II.

Peter Galison studies the work of physicists of which other physicists say that it is «no longer physics».[10] In particular, he focuses on certain conceptions of string theory, nanotechnology, and simulation modelling. He is careful not to pass judgement on whether or not the contested work is, in fact, physics. He is equally careful not to rank this work as inferior, methodologically deficient or epistemologically naïve. Instead, he is interested to show what might be meant by the claim that something is «no longer physics.» He identifies the fault-line of the debate as the question of ontological indifference: Is it the task of physics to ascertain first and foremost what is or isn't the case, what the building blocks of matter are, what is artefact and what reality, what a necessary feature of a conceptual model and what a measurable

8 To these different ways of conceiving scientific experiments epistemologically and aesthetically correspond different ways of experimenting in the arts, see: Alfred Nordmann: Experiment Zukunft: Die Künste im Zeitalter der Technowissenschaften. In: *subTexte 03: Künstlerische Forschung – Positionen und Perspektiven*. Zürich 2009, pp. 8–22.

9 Alfred Nordmann: ‹Getting the Causal Story Right›: Hermeneutic Moments in Nancy Cartwright's Philosophy of Science. In: Stephan Hartmann et al. (Eds.): *Nancy Cartwright's Philosophy of Science*. New York 2008, pp. 369–388.

10 Peter Galison: The Pyramid and the Ring. Presentation at the conference of the *Gesellschaft für analytische Philosophie* (GAP). Berlin 2006.

process? Certain approaches to string theory, nanotechnology, and simulation are indifferent to such questions. They care not about the existence of things but about their properties and functions and what to make of them.

Where building takes the place that was formerly occupied by knowing, where «what works?» takes the place of «what is?» and where «how can we extend our capabilities?» takes the place of «how is the world hierarchically organized?» scientists are still involved in basic research. Even when physics goes beyond the purview of physics, classically conceived, this research does not directly lead to technical applications, it does not necessarily consist in scientists working on the creation of devices, and it does not always respond to societal demands or specific human needs. And yet, Galison accurately refers to an «engineering way of being in science». To put the point more generally, ontologically indifferent technoscientific research is not about the true description of the world and not about the functioning of devices but consists in the acquisition and demonstration of basic capabilities.[11] In particular, these are basic capabilities of visualization and manipulation as embodied in the scanning tunnelling microscope as an icon of nanotechnology.[12]

Even though basic technoscientific research need not be application-driven, it is research in a context of application. It can afford ontological indifference only to the extent that it can rely on the fact that its objects of research as well as its modelling tools belong to a world that is already the product of science and technology. Ontologically indifferent research is parasitic on the pervasive technical implementation of the knowledge produced in the 19th and 20th centuries. In a somewhat loose manner of speaking, technoscientific research takes place in the medium of science and technology. In this medium, there is no linearity of application from one domain – namely, scientific theory – to another domain, namely technical capability. Instead, what is applied is science and science-based technology as a whole and what is applied are the scientists themselves: A large repertoire of theoretical resources, of laboratory skills, of modelling techniques, of black-boxed instruments, of interdisciplinary collaborations is applied to the production, explanation, control of novel phenomena. These phenomena in turn, and thus the objects of research inhabit the knowledge society, they require for their existence the contemporary technologized world and are not eternal inhabitants of nature that are only now brought to the light of day.[13]

All this suggests that technoscientific research takes place within a self-contained world or second nature which in the form of scientific knowledge, technical instruments and practices takes up or absorbs much of the «natural world» or first nature.

11 Alfred Nordmann: Philosophy of Nanotechnoscience. In: Günther Schmid et al. (Eds.): *Nanotechnology*. Vol. 1. Günther Schmid (Ed.): *Principles and Fundamentals.* Weinheim 2008, pp. 217–244.

12 Davis Baird et al.: Probing the History of Scanning Tunneling Microscopy. In: Davis Baird et al. (Eds.): *Discovering the Nanoscale.* Amsterdam 2004, pp. 145–156.

13 Here, the philosophy of technoscience links up with sociological accounts of a «reflexive» second modernity (Ulrich Beck et al.).

By the same token, the relation between these worlds becomes opaque and thus the relation between the technoscientific presentation of effects to the phenomena in the «real world out there.» In other words, where ontologically vigilant science tends to the gap between the sphere of representation and the sphere of what is to be represented, there is no such gap for ontologically indifferent technoscience: It moves laterally between practices of production, construction, visualization, modelling and assumes that these practices lead to the discovery and control of dynamic processes that obtain in the «world out there» just as much as they do in the technoscientific context of application, if only because the latter partakes in the former.[14]

This is not the place to fully elaborate, let alone justify all these claims about technoscience. In particular, it cannot be argued here whether and to what extent technoscience is something novel. Also, it cannot be shown why and how technoscience *can afford to be* ontologically indifferent. Instead, a particular aspect is to be singled out: How do scientists behold their objects in ontologically vigilant science and within the engineering way of being in science? How does a manner of beholding constitute the scientist along with the object as an object of scientific experience? Or inversely, what kind of attitude towards the object is implied by research interactions, how does the object appear in scientific experience?

A very schematic history might distinguish several stages but the focus here is even more schematically on just two. These stages are distinguished by the representational practice of modern science as an artful construction of immediacy and by characterizing the immersive practice of technoscience as a symbolic substitution of a dynamic system of nature by a technologically constructed dynamic system.

The artfully artless construction of a scene is characteristic for the laboratory of modern science where an experiment is set up to enable the exhibition of nature. It is underwritten by a dispositional account: The phenomena of nature were always there, lying ready to manifest themselves when prompted. Laboratory technology and the experiment finally provide that prompt for the phenomenon to show itself. Here, the experimenters can maintain a clear conceptual distinction between what they have done and what nature does; they can transition from their role as prompters who actively set the stage to that of witnesses or spectators. The phenomena can speak to them as if on their own accord, the simplified laboratory constructions appear as if they were unadulterated nature, the models of reality are taken as if they were reality itself. Such «as if»s need to be artfully maintained; the necessary distinctions require a work of purification that typically consists in distinguishing experimental artefacts from meaningful measurements, controlling variables, or finding out what in our conceptualizations belongs to nature and what belongs to the apparatus required for picturing nature. Scientists as masters of the «as if» thus solve a problem of representation: Well aware that the representation

14 For this and much of the following see Alfred Nordmann: Collapse of distance: Epistemic Strategies of Science and Technoscience. In: *Danish Yearbook of Philosophy* 41, Kopenhagen 2006, pp.7–34.

and what is represented cannot be immediately compared but are separated by an abyss of «aboutness», they create conditions under which nature appears to spontaneously and immediately agree or disagree with its representation: The gap between a mental construct here and a physical event there can be closed when the event yields a measurement or confirms a prediction.[15] The very difficulty of producing a true representation of the world thus prompted a variety of artful constructions of immediacy, that is, methodologically crafted institutions that let nature speak as if untutored. Ontological vigilance is just another word for an awareness of these difficulties.

It is the progress of representational techniques that prepared the shift from representation to symbolic substitution. Technoscientific representations are so good, that is, so saturated with reality, that they stand in for reality itself rather than refer to a reality «out there». So, here we encounter again the collapse of distance that comes with the neglect of the aboutness-relation between the representation and what is represented. This is not to say that technoscientific visualizations and models are not meant to refer to a reality beyond themselves. Instead, this is to claim only that their relation to an external reality is for the most part taken for granted, that its details often remain opaque, and that it requires a special and highly specialized effort to recover the representational qualities of these models. The unquestioned assumption of an opaque representational quality is another word for ontological indifference.

Two examples make that point. Medical and pharmaceutical research frequently relies on so-called animal-models of disease. Sometimes these animal-models are genetically engineered like the infamous cancer-mouse.[16] The animal offers a living substitute for a human breast-cancer patient. Researchers can spend their entire careers studying the animal model without asking how the model represents human cancer and without transitioning from the animal model to a human patient. As they watch tumors grow and shrink, they cannot resort to a dispositional account that permits them to separate the work of technology and the work of nature: It is not the case that experimental interventions prompt the manifestation of natural phenomena. After all, the dispositions of the cancer-mouse, and foremost its disposition to get cancer, are themselves a product of engineering for the purposes of experiment. And what is engineered is not a single experimental artefact but a population of genetically identical mice, and thus a whole second nature with its laboratory ecology. This second nature is thought to partake in the world of the cancer patient. The use of the animal model is justified in general terms by the straightforward idea that the disease process in the cancer mouse shares in the dy-

15 The foregoing characterization relies on various case-studies and amalgamates much Science Studies scholarship. For at least some more detail see the paper referenced in note 14.

16 Again, the following is informed by numerous accounts, first and foremost the one in Donna Haraway's *Modest_Witness@Second_Millenium.* New York 1997.

namics of breast-cancer growth more generally. Since the animal model and the human cancer victim are thought to participate in the same dynamic process of tumor growth, it should be possible one day to transfer what one has learned about the animal model to the human patient. In the meantime, research is totally immersed in the substitute reality. While this substitute reality is heavily invested with features of the intended reality-of-interest, it is a formidable task to recover just how, precisely, this substitute reality serves as a representation of the reality-of-interest. And since researchers are working to heal human cancer by healing cancer in mice, this formidable task would undermine this confidence of purpose – suddenly, the animal model would appear as a model of a state of affairs other than itself.

The second example contrasts the ball-and-stick models of molecular structure of the 19th century with the animated and interactive 3-D molecular imaging software of today. It is hard to overlook the discrepancy between model and reality when the model itself is crudely constructed to aid human imagination. Indeed, the early models wore their constructedness so openly on their sleeves and were so clearly expressive of a conceptual or explanatory structure that their users generally subscribed to positivist vigilance[17]: «since all we know are the models of our constructions, we know nothing of reality». In contrast, users of immersive and interactive software enter the cavernous world of molecules, analyze structures, discover potential bonding sites and thus afford their ontological indifference: «these models are so saturated with reality that all we need not to learn about reality can be learned right here.»

In both examples, representation has given way to symbolic substitution. At the same time, the artful construction of a scene in which the constructed phenomenon can appear as the artless manifestation of nature gives way to immersion in a substitute reality of dynamic processes that are thought to participate in the dynamics of the natural as well as socio-technical world. Representation requires that the careful opposition of the sign and signified, of knower and known yet permits an agreement between the two. The improvement of representational instruments and techniques produced a collapse of these oppositions. They allow for the incorporation into a substitute reality of the subject and the object of research as they are entangled with one another by way of the socio-technical world of which they are both participants.

To be sure, this tentative diagnosis only sets the stage for a research agenda into this kind of incorporation, how it comes about and what it means. So, like some of the other essays in this collection of momentary analyses, this one concludes with research questions rather than answers. Epistemologically, for example, one needs to ask about inferences from similarity when observations of the substitute reality (e.g., simulation experiments) are taken as the basis for judgements about

17 Christoph Meinel: Molecules and Croquet Balls. In: Soraya de Chadarevian et al. (Eds.): *Models: The Third Dimension of Science*. Stanford 2004, pp. 242–275.

«real-world» phenomena. Since what we see in the calculated picture looks like the picture obtained from empirical data, we conclude that the empirical data are due to a similar dynamic process as the one modelled in the simulation. Traditionally, such arguments from similarity have been considered highly suspect, but might they be warranted where the substitute reality is constructed from the tool box of successful theories and algorithms and centuries of accumulated scientific and technical knowledge?

There are further questions, some concerning the philosophy of technology and the demand for transparency and control: Does the opacity of immersive and interactive rather than representational relations leave us with a magical sense of wonder how well things can work when the world is on their side, when they participate properly in its dynamic structure? Then there are many questions regarding the way in which the incorporation of the subjects and objects of research into a substitute reality is supposed to work: Does it rest on the supposition that all one needs are algorithms which express functional relations between properties and traits, and that these then allow us to move with ease between an insubstantial «natural« world and the symbolic substitutes that can fully absorb us? And in an essay on epistemological as well as aesthetic dimensions of research, there must also be aesthetic considerations. The artful «as if» of the modern scientists can be described as a proper balance between absorption and theatricality.[18] It involves the construction of a vantage point from which scientists can be transfixed by the constructed scene in the laboratory, but transfixed in such a way that they do not appear as actors on their own stage. This is the view from nowhere, the gaze of objectivity. How is this view from nowhere transformed by the immersive and interactive experience of scientists who step into cavernous worlds and seem to move within and among them? And how is objectivity transformed when the objects of research become invested with social meaning and physical dynamics as is the case, for example, with the cancer-mouse? When research-objects become animated, literally and figuratively through animation-techniques, do they become research subjects and does it require a critical media theory to restore their representational meaning and thus their objectivity?

Perhaps, the artful apprehension of the landscape is a modern achievement that relates the observant and critical subject to a civilized and acculturated nature. The opposition of subjects and objects of research testifies to their interdependence, perhaps mutual constitution. Along Kantian lines one might say that by setting the stage on which nature can be observed, scientists cast themselves as sovereign lawgivers of a lawful nature. In contrast, technoscientists submit themselves to nature and its endless play of similarities by seeking to control it from within. As the notions of similarity and submission, immersion and substitution, simulation and participation suggest, technoscientists might just be pre-modern shamans and

18 Michael Fried: *Absorption and Theatricality: Painting and Beholder in the Age of Diderot*. Berkeley 1980.

tinkerers in a world that is shaped by modern science and technology. By choosing to return into the cave[19], they question what the landscape once taught us about distance and respect, about representation and truth, about limits of knowledge and control.

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19 With surprising eloquence, the Wikipedia entry on the «Cave Automatic Virtual Environment» notes that «The name is also a reference to the allegory of the Cave in Plato's Republic where a philosopher contemplates perception, reality and illusion» (*Wikipedia, The Free Encyclopedia*, en.wikipedia.org/w/index.php?title=Cave_Automatic_Virtual_Environment&oldid=327636238; 23.12.09). Of course, the return to Plato's cave is the return to a prison of sorts, and what imprisons the inhabitants is ignorance about the nature of representation – they assume that the pictures on the walls give them immediate access to reality.

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