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Design and Referentiality in Analogue and Digital Photography

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1. 'Reality' vs. 'Manipulation'

As far as the history and theory of visual media are concerned, we are probably completely justified in maintaining that the most widely discussed turning point or upheaval in recent years has been the spread of so-called 'digital images'. Each of us is now surrounded by computer display images and sees computer-generated images, etc., in the cinema and in television. The conceptualization of this transformation has for about the last 20 years now stubbornly revolved around the same topoi. The principal one is the claim that the image's reference to a particular 'reality' is lost through the spread of numerous digital images, images that are visually *indistinguishable* from photographs. This reference, it is claimed, was guaranteed by the fact that photographs are linked via light indexically, that is, causally, with the object being photographed. Two examples of this may suffice: As early as 1990 Fred Ritchin warned that photojournalism and its role in bearing witness to real events would come to an end with the arrival of computers.ⁱ In 1994 no less than Jean Baudrillard claimed that 'reality [has] already disappeared from the synthetic image'.ⁱⁱ

Now it could be assumed that this may be an antiquated debate from the early 1990s, when there was still plenty of debate, at least as far as the world-transforming role of the 'digital revolution' was concerned. Not at all: In 2004 Bernd Stiegler again writes a text on 'digital photography': Here too the diagnosis is presented: 'The transition from analogue to digital photography has radically transformed photography's discursive as well as ontological status.' With recourse to Friedrich Kittler's well-known phrase that 'computer images [are] falsification itself',ⁱⁱⁱ Stiegler comes to the hardly surprising conclusion:

'In contrast to analogue representation, of which a continuous translation is characteristic, in the case of digital photography the translation of an image occurs within a fixed grid and graticule pattern in which each individual point or pixel is determined by a numerical value and may accordingly be arbitrarily processed and transformed. [...] We are standing – this is made more than abundantly clear by this pointed characterization – at the end of the photographic era. The pictorial evidence of photography is dead, the presumed authenticity of

the photographic image is a chimera [...]. Photography as an authentic document has played out its role.^{iv}

One nonetheless soon suspects that something about this is wrong, since it remains unexplained why today, and even long ago, doctors, scientists, meteorologists, soldiers have scarcely relied on analogue but instead on digitally reworked or produced images in order to analyse and in some cases transform a specific ‘reality’ – be it that ‘of the body’, ‘of nature’, ‘of the weather’ or ‘of the enemy’. What a nightmare it would be if the images that the computer tomograph takes of me before an operation – in this case digital ones – ‘had played out their role as authentic documents’: Would you still allow yourself to be operated on? Hardly. Stiegler himself suspects that there is something wrong about this: ‘Today, obviously nearly all professional press photographers who are still concerned about the pictorial documentation of events work with digital equipment in order to be able to transmit images to the editorial department already during an exciting football match or a turbulent party conference.’^v And further: ‘Of course all most all amateur photographers use their digital camera like a classical Leica [...].’^{vi}

But: All these obvious facts hardly challenge Stiegler’s radical ontological rupture: ‘All this is not decisive [...] More decisive are rather the consequences that have arisen as a result of the digitalization of photography as a whole, without their having been applied in detail and in universal practice.’^{vii} Here the argument becomes in my opinion manifestly shaky: How can digital photography *actually be* nothing but ‘falsification itself’ (Kittler) and yet be continued to be *used* merrily and freely as documentation?

In my view the fundamental problem of this entire discussion lies in the fact that an unquestioned dichotomy is spooking in the background: *And this involves that between so-called ‘reality’ and ‘manipulation’*. *First*, it is assumed that only a somehow untouched, unchanged image could possibly convey ‘reality’ – as if the very possibility of recording a photochemical image were not in itself already something very artificial. Peter Galison and Lorraine Daston have precisely brought out the historicity of this idea.^{viii} *Second*, it is argued that every single intervention in the photographically acquired image automatically and inevitably removes it from ‘reality’. Only on the basis of these two assumptions may the (as I will attempt to show) absurd claim be formulated that images present in the form of digital data represent, merely because they *are easier to process*, almost automatically the end of ‘documentation’, of referentiality, of the reference to reality, or whatever else one wishes to call them.

In the following I would like to deconstruct, as it were, the dichotomy between ‘reality’ and ‘manipulation’.

1. First, one can argue from a *media-historical* standpoint – it can be shown that the development at least of image processing procedures particularly in astronautics and espionage were precisely intended through interventions in the *design* of photographic images to bring about greater reference to reality. This means that here media and design issues already coincide.
2. Second, I would like to delve into this observation somewhat theoretically and, in doing so, refer back to *science studies*, particularly to Bruno Latour.

2. A Very Brief History of Digital Image Processing

Let us plunge into the history of digital image processing. Image processing means: Here it is not a matter of ‘the digital image’ in toto. Under the headword ‘digital images’, two different types of images are often combined indiscriminately. These include, on the one hand, scanned, i.e., *digitalized*, and, on the other hand, algorithmically *generated* images such as are common, say, in the ‘photorealistic’ graphics of Hollywood cinema. Here I would like to deal only with the first type, digitalized images. We are all constantly being confronted with such images: When you place an original, for example a catalogue of Andreas Gursky, on your flatbed scanner and scan it, when you use your digital camera, for example when you are on holiday, light falls through a lens system on to a photoelectronic sensor, a CCD. The voltage levels measured pro pixel are transferred by means of an A/D converter to a numerical matrix. The digitalized images link up with photographic images insofar as that they are based on the scanning of light. Here it is revealed for the *first* time why the desperate opposition being made between digital, more precisely digitalized images, and analogue photography is hardly plausible, for in the case of the scanner or the digital camera light also falls – indexically – from the object on to the sensor. To be sure: The latter does not capture the image in such an entropically irreversible manner as is the case with chemical film – Wolfgang Hagen has shown this admirably^{ix} – but the term photo-graphy initially means simply ‘light-writing’. Nothing about this concept justifies why this ‘writing’ should necessarily be only chemical rather than photoelectronic in nature. Admittedly: Hagen too emphasizes the fact that the data that are derived in this way may be more easily transformed.^x But here my *second* and main argument comes in: Why is the possibility of change a priori a deviation from the trace of the real? It is rather the case, as I would like to demonstrate to you directly, *that this trace must*

be cleared of noise and interference if it is to appear in the first place! The possibilities for digitalizing images were only invented to process images. And this processing had only *one* goal: namely to learn more about a particular so-called ‘reality’. At this point I cannot enter into the numerous precursors and details of this history – they are also unnecessary.^{xi} I would only like to mention one significant case from the 1960s.

In preparation for the Apollo programme, that is, the manned moon landing, the Ranger programme was started. The purpose of the Ranger probe was to send video images of the moon's surface back to earth. One had to know of course where one wanted to land. The first Ranger missions failed. Only Ranger 7, started on 28 July 1964, first sent analogue video signals back to earth using a new type of vidicon tube.^{xii} There the images were processed and

reworked at the *Information Processing Laboratory* (IPL) founded in 1965 at the instigation of Dr. Robert Nathan as part of NASA's *Jet Propulsion Laboratory* (JPL).

For this purpose, later so-called VICAR (*Video Image Communication and Retrieval*) software on an IBM 7094 or IBM 360 was used.^{xiii} In this way, knowledge was gained about the reality of the moon's surface. Very soon the people working at the IPL came up with the idea of also applying the image processing procedures to the enhancement of medical images, at first X-rays. In 1967 Nathan and Robert Selzer presented their findings to the *National Institute of Health*, where the enthusiasm was so great that one supported the research at the IPL financially.^{xiv} In particular the correction of geometric distortions through *image warping*^{xv} (refer to the image once again) was soon intensively employed in medical image processing, above all in *digital subtraction angiography*, which was clinically evaluated for the first time in 1981, in order to establish precise diagnoses.^{xvi} In this way knowledge is acquired about the reality of the body. To summarize the results quickly: It is evident from all of these examples from espionage, astronautics, science and above all medicine that the *processing*, the manipulation, was and is the very *condition* for the referentiality of the images: '*However imagery is obtained, it requires processing and*

interpretation to convert it into intelligence data. Computers can be employed to improve the quantity and quality of the information extracted.^{xvii}

Here an example of the early medical application of image processing can be seen. An image of an artery – taken in the context of a heart attack examination. Above hardly anything can be seen – below, following the digital processing, considerably more can be seen. When seen in this way, design (*Gestaltung*) is not something artificial that overlays an original trace secondarily – design (*Gestaltung*) is the very precondition for being able to make sense of a trace in the first place.

Actually this ought to be self-evident. Even the most analogue of photos are subject to this principle. Barthes' famous exclamation that every photo tells us '*That's how it was*' at first presupposes in a quite banal way that the 'That' and the 'how' can be identified in the first place. And this depends at least on two factors. *First*, certain conventions or design parameters affecting the taking of the photographs and their development have to be met. If the exposure is selected for too long, photos become overexposed or motion-blurred to the

point of being unrecognizable. This is admittedly banal. But that is precisely what shows that referentiality is not something that is ensured simply through the analogue nature of a particular technology. *Second:* Even if the design is set up to produce the correct recognizability, this still does not mean that the ‘That’ and the ‘how’ automatically come into play. Even if, for example, people can be recognized, that still does not mean that one knows who it is and in what situation. Again: This is admittedly banal. But just because of that it should not be forgotten. It is precisely the contextualization through image captions, etc., to which Barthes has, moreover, explicitly referred in his early, semiotically marked works, that becomes essential in the case of scientific photographs.

This image shows one of the most important photos from the history of particle physics, a *golden event* as Peter Galison has called it. Nonetheless, this image at the time of its production in 1964 was still not recognized as *the* evidence we see it as today. As further

indications began to accumulate, the image was recognized as the first photo of an event during which an omega minus boson is produced and disintegrates. You cannot see this because you lack the knowledge surrounding the event. You cannot point to the photo – with the gesture that Barthes describes so beautifully in *La chambre claire*: *that, precisely that, this alone is it*.

With the commentary scheme such as it is now also printed in today's legendary publication of 1964, it perhaps becomes a little bit clearer. At least if you know that it had to do with the search for the omega minus, you can infer from the scheme that this tiny kink in the photo is what is important – *that, precisely that, this alone is it*. And what it is exactly? To the left you can see photo number 97,025 of a series of experiments conducted at the Brookhaven Laboratory, New York. On the background: In the American laboratory for particle physics, researchers had set up a bubble chamber filled with approximately 1,000 litres of hydrogen. A beam of negatively charged kaons was shot into the laboratory's 80-inch tall bubble chamber. During the collisions of the beam with the atoms, numerous new particles arise which, dependent on their charge and their mass, leave behind traces resembling tiny condensation trails. But only one particle interests the researchers – namely the particle with the nondescript name ' Ω^- '. Murray Gell-Mann was the first person to assert the existence of this particle as early as 1962 to his colleagues at an international conference. Gell-Mann could predict the particle and its precise characteristics, since he had discovered a new regularity in the previously rather confusing particle zoo, namely so-called ' $SU(3)$ symmetry'. This theory

was confirmed by the evidence of the traces on photo number 97,205. Already by the simple fact that it was the 97,205th image on which the sought-after traces occurred does it become clear how much media effort had been put into the particle chase. A film was passed at high speed over the bubble chamber in order to capture the countless and disorganized collision events. After the bombardment had ended, the film had to be evaluated one image at a time. For this purpose there were entire teams of specialists (called ‘scanners’) who looked out for suspicious traces. If pieces of photographic evidence were found, they then had to be interpreted. Because: the few slight and confusing lines that the light had drawn on the photosensitive material gave no indication on their own of what they represented. In any case: The 97,205th image together with its interpretation – the hunted and short-lived Ω^- – is the small kink to the right in one of the lines – became a virtual icon of particle physics. It convinced most physicists that Murray Gell-Mann’s theory was correct – today under the concept ‘quark model’ it has thus risen to become one of the supporting pillars in the so-called ‘standard model of particle physics’.

From all of these examples of analogue and digital photography taken from the media, design and science, it is impossible, however, – as Michel Foucault states – to derive a ‘monotone [...] finality’^{xviii}, which as a result of manipulation never represents a problem: There is a limit between ‘forbidden intervention and approved correction’^{xix}, which, depending on the practice involved, may be exceeded at different rates. Everyone here who has ever produced a book knows that illustrations are nearly always reworked using *Photoshop* in order to make them sharper and give them more contrast. No one would describe this as falsifying manipulation. Since, however, according to Luhmann a permanent ‘suspicion of manipulation’^{xx} is part of the system of the *mass media*, it is hardly surprising that particular attention is granted there to the easy workability of digital images, one which, moreover, thanks to the PC and Adobe is also available to any amateur.^{xxi} This illustrates the fact that doubts concerning the credibility of analogue and digital images depend primarily on the type of discursive practice in which the images operate. There are many analogue photos of UFOs but are they seen as ‘unquestionable evidence’ of the fact that UFOs ‘really’ exist? Hardly. Knowledge of the history of digital image processing unmasks the opposition – one that has been exaggerated as an ‘ontology’ – between ‘reality’, which presumably may still be found in analogue photography, and the presumably unreal quality of ‘digital manipulation’ simply as ideology, so to speak. Where this ideology comes from may for the moment remain unanswered.

Before I turn to the second part of my paper, I would still like to discuss briefly an issue that surely must suggest itself to many of you now. Does my argumentation then mean that there is no difference between ‘analogue’ and ‘digital’ photography, to use these simplistic generic terms? Not at all. Digital data have to be archived in a different way. They can circulate in a different way than analogue images – each of you has undoubtedly sent images by e-mail – and they can, as I have shown, be processed in an entirely different way. Different forms of technology have different potentials which, however, in my opinion may not be negotiated abstractly from a *macrological* – ‘ontological’ – standpoint. Rather, it can only be a question of investigating in detail concrete discursive practices and their respective application of analogue and/or digital visual media – as would, say, a history of science trained according to Bruno Latour. Through detailed studies of scientific practices Latour has examined the particular ways in which referentiality, ‘reality’, is produced – and in the very same *micrological* way one ought to study the practices of analogue and/or digital photography: Be these ‘everyday’, scientific – or artistic.

3. Reality and Construction in Latour

For spies, soldiers, but also for doctors and scientists, the result of their painstakingly ‘constructed’ image processing is precisely this representation of a particular operational ‘reality’. As early as 1931 Bertolt Brecht observed that ‘less than ever can a simple “reproduction of reality” say something about reality. A photograph of the Krupp factory or AEG tells us hardly anything about these institutions. [...] Thus something actually has to be constructed, something “artificial”, “posed”’.^{xxii} This is something artificial, posed, is precisely not the opposite of knowledge concerning ‘the real’, but rather its very precondition. Every laboratory is something artificial, posed, which precisely *because of* its artificiality enables knowledge about reality.

Bruno Latour, who has already been mentioned, stresses the ‘striking phenomenon of artificiality and reality marching in step’^{xxiii} which is characteristic of scientific research. And: ‘Every scientist we studied was proud of this connection between the quality of its construction and the quality of its data.’^{xxiv} Latour’s concept of construction in no way implies that knowledge about ‘reality’ is *only* constructed in the sense that it could just as well be constructed otherwise (for example dependent on variable ‘social factors’), but rather only that there is a need for what is usually digital image processing or such expensive constructions as particle detectors if one is to learn something about a specific ‘reality’.^{xxv}

‘Work and montage’ (Latour) are required in order to achieve results. This does not mean, however, that the results would differ according to contingent (social) circumstances: Knowledge, for example, of laws of nature such as the constancy of the speed of light in a vacuum does not drop from the skies, it is not manifested simply *on its own* by an often invoked ‘nature’. Rather, such knowledge of ‘nature’ must be wrested by ever more subtle, institutionally and technically ever more complex experiments – but by this means the laws of nature are not *made* arbitrarily. To follow up very briefly with what Popper has to say: Without experimentation no physical theory can be tested and all suitable results only confirm it until an experiment occurs that does not fit in with its predictions – which the theory as a rule falsifies. But experimental systems (Rheinberger) do not grow on trees. They have to be skilfully constructed in agreement with the questions being asked.

‘When we say that a fact is constructed, we simply mean that we account for the solid objective reality by mobilizing various entities whose assemblage could fail.’^{xxvi} In this sense facts are – the word comes from the Latin *facere* to make – *constructed*. A fact is precisely a fact (*Tat-Sache*).^{xxvii} Thus there are cases such as heavy ion research in which transuranic elements, *which rarely or never occur in nature*, are produced in order to gain insights, for example, into the *real* structure of atomic nuclei. ‘Every scientist we studied was proud of this connection between the quality of its construction and the quality of its data.’^{xxviii} And with advances in science the experiments become increasingly complex and require increasingly more *construction*, which requires more and more money and the willingness of the respective authorities to invest it in experiments that appear to the greater mass of the public to be entirely useless. The work of construction is not decisive for the *what*^{xxix} of scientific knowledge, for example, but rather for its *that*.^{xxx}

4. A Very Short Conclusion

In conclusion the main theses being presented here may again be summarized briefly:

1. The still widely diffused thesis according to which analogue photography = reference to reality, evidence, referentiality, documentation vs. digital photography = unreal, ‘falsification itself’, non-referential, self-referential, is false. It is based
2. implicitly on the dichotomy: ‘reality’ vs. ‘manipulation’ (processing). This needs to be questioned historically and from a media-aesthetic perspective, that is, proceeding from the design. ‘Reality’ is not rigidly given but instead has to be produced through

continuous work – which does not mean, on the other hand, that it can be ‘constructed arbitrarily’.

3. Consequently, analogue and/or digital image production methods operate in different ways, in different discursive practices (for example, science or art), by means of which different forms of reference, of specific knowledge concerning a specific ‘reality’, may be produced.

The response to one question remains open: How has it occurred that at the beginning of the 1990s – and still powerful even today – the notion emerged that digital images are per se devoid of reference – in contrast to analogue images? It may be assumed that postmodernist discourses that were still very powerful at the time and which in the figure of the above-mentioned Jean Baudrillard anyhow saw reality as disappearing in the ‘non-referential simulation’^{xxxii} of the mass media viewed the emergence of digital images as a fitting confirmation of their own theses. It is possible that the stubborn insistence on ‘non-referentiality’ may be seen either as an ideological expression of a late-capitalist economy that had itself become ‘devoid of reference’^{xxxiii} or that, optionally, it betrays symptomatically the desire for release from painful reality or precisely the desire for a return to it.

Whatever the case may be: In any case we can say that the construction (in Latour’s sense of the term) of ‘reality’ is not something that has to do solely with the difference between analogue and digital. Both types can serve as tools needed in order to open up ‘reality’ in different ways.^{xxxiii} And with both types of images, ‘non-referential’ fictions, falsifications and deceptions can and could be constructed. The distinction between analogue/digital does not ease the burden on us to perform the difficult work of describing historically and/or in terms of participatory observation individual practices using images. Only by using *Long Lost Friends* 1. the history of the media, 2. design forms in these media, and 3. practices, for example of a scientific nature, in which these media and their forms operate, can something be said about the referentiality of images. Media potentials are one thing, semiotic processes are another. The ontologies of the analogue and the digital are not the answer.

ⁱ Cf. Fred Ritchin, *In Our Image: The Coming Revolution in Photography; How Computer Technology is Changing Our View of the World*, New York, 1990; id., 'The End of Photography as We Have Known It', in: Wombell, *Photovideo*, pp. 8–15 and id., 'Photojournalism in the Age of Computers', in: Carol Squiers (ed.), *The Critical Image. Essays on Contemporary Photography*, Seattle, 1990, pp. 28–37.

ⁱⁱ Jean Baudrillard. 'Das perfekte Verbrechen'. In: Hubertus von Amelunxen (ed.). *Theorie der Fotografie IV 1980–1995*. Munich: Schirmer/Mosel 2000, pp. 256–260, here: p. 258. It is unclear to me what Baudrillard means by 'synthetic image', since in my view all images have to be called synthetic (with the possible exception of mirror images – but are those really images? Cf. Umberto Eco. 'Über Spiegel'. In: id., *Über Spiegel und andere Phänomene*. Munich/Vienna: Hanser 1993, pp. 26–61). Probable in the context of the quote is that Baudrillard has in mind computer-generated images (see below) – which still do not makes sense, however, since it can be shown that even from generated images the real has in no way disappeared.

ⁱⁱⁱ KITTLER COMPUTERGRAFIK: 179

^{iv} Stiegler, 108/109/110.

- the 'presumably' would also permit the conclusion that Stiegler really means that with the advent of digitalization doubt would also been cast on analogue photography, that is, that no image would appear more or less but only otherwise referential, authentic, credible: but then the sentence rejects this possibility, which is not what I do here.

^v Stiegler, 106/107.

^{vi} Stiegler, 107.

^{vii} Stiegler, 107.

^{viii} GALISON / DASTON

^{ix} HAGEN: Entropie

^x HAGEN: Digital' we can produce as many images as we like, overlay them, mix them, fractalize them, 'dither' with them, etc., without in the process losing even a single pixel.

^{xi} See my other texts

^{xii} Cf. URL: nssdc.gsfc.nasa.gov/nmc/tmp/1964-041A-1.html, 5.1.2004. On the method of the vidicon tube, cf. Wolberg, George: *Digital Image Warping*, Los Alamitos 1990, pp. 33/34.

^{xiii} Cf. Billingsley, Fred C.: 'Processing Ranger and Mariner Photography', in: *Journal [of the] Society of Photo-Optical Instrumentation Engineers*, Vol. 4, No. 4 (April/May 1966) pp. 147–155. Billingsley, p. 147, mentions the IBM 7094, while Sheldon, Ken: 'Probing Space by Camera. The Development of Image Processing at NASA's Jet Propulsion Laboratory', in: *Byte* (March 1987) pp. 143–148, here p. 145, maintains that an IBM 360/44 was used at the IPL.

^{xiv} Cf. Sheldon: 'Probing Space by Camera' (note 24), pp. 145–147. See also NASA (pub.): *Astronautics and Aeronautics, 1967. Chronology on Science, Technology and Policy*, Washington, D.C. 1968, p. 104.

^{xv} Cf. Billingsley: 'Processing Ranger and Mariner Photography' (note 24), pp. 153/154 and Billingsley, Fred C.: 'Applications of Digital Image Processing', in: *Applied Optics*, Vol. 9, No. 2 (February 1970), pp. 289–299, especially pp. 292–294. On the mathematical and computer-scientific foundations of warping see in depth Wolberg: *Digital Image Warping* (note 23).

^{xvi} On DSA, cf. Meijering, Erik H.W./Zuiderveld, Karel J./Viergever, Max A.: 'A Fast Technique for Motion Correction in DSA [= Digital Subtraction Angiography] using a Feature Based, Irregular Grid', in: William M. Wells/Alan Colchester/Scott Delp (eds.): *Medical Image Computing and Computer-Assisted Intervention*. MICCAI 98 Proceedings, Berlin, etc. 1998, pp. 590–597.

^{xvii} Richelson: 'US Satellite Imagery' (note 19), Emphasis by J.S. Cf. Billingsley: 'Applications of Digital Image Processing' (note 26), p. 289. On image processing in the assessment of other satellite data as well as in that of weather satellites, see Haralick, Robert M.: 'Automatic Remote Sensor Image Processing', in: Azriel Rosenfeld (ed.): *Digital Picture Analysis* (Topics in Applied Physics, Vol. 11), Berlin, etc. 1976, pp. 5–63.

^{xviii} Foucault, Michel: 'Nietzsche, die Genealogie, die Historie', in: id.: *Von der Subversion des Wissens*, Frankfurt a.M. 1987, pp. 69–90, here p. 69.

^{xix} Alex Soojung-Kim Pang, in GEIMER, p. 104. See also Edgerton/Lynch: 'Aesthetics and Digital Image Processing'

^{xx} Luhmann, Niklas: *Die Realität der Massenmedien*, Opladen, 2. Aufl., 1996, pp. 9 and 31.

^{xxi} Some examples of these are cited in Rosler, Martha: 'Bildsimulationen, Computermanipulationen', in: Hubertus v. Amelunxen/Stefan Iglhaut/Florian Rötzer (eds.): *Fotografie nach der Fotografie*, Dresden/Basel 1995, pp. 36–57. The commotion about these digital reworkings is surprising alone because – as Rosler has also stressed – manipulation and processing have in the same way been part of the history of photochemical photography from the very outset.

^{xxii} Bertolt Brecht, *Gesammelte Werke*, Frankfurt a.M. 1968. Vol. 18, pp. 161/162.

^{xxiii} Bruno Latour, *Reassembling the Social. An Introduction to Actor-Network-Theory*, Oxford 2005, p. 90.

^{xxiv} Latour, *Reassembling*, p. 90.

^{xxv} Cf. Jens Schröter, 'Der Äther des Sozialen. Anmerkungen zu Bruno Latours Einstein-Rezeption', in: Albert Kümmel-Schnur/Jens Schröter (eds.), *Äther. Ein Medium der Moderne*, Bielefeld 2008, pp. 367–393.

^{xxvi} Latour, *Reassembling*, p. 91.

^{xxvii} The concept 'construction' has in many languages the stale overtone of that which has been put together arbitrarily and unjustifiably, particularly when it is extended to cover the concept of 'social construction'. Latour, *Reassembling*, p. 91, thus draws a sharp demarcation line between his preferred 'constructivism' and 'social constructivism'. In German the term 'Konstruktivismus' is in turn defined by the theoretical tradition of 'radical constructivism', with which Latour has nothing in common.

^{xxviii} Latour, *Reassembling*, p. 90.

^{xxix} Of course there are cases in which, for example, expert opinions in the service of specific, private interests result in tendentious or downright false knowledge. But such 'manipulations' are not our focus here.

^{xxx} On the primacy of 'that' over 'what', see Bruno Latour, 'Technik ist stabilisierte Gesellschaft', in: Andréa Belliger/David J. Krieger (eds.), *ANThology. Ein einführendes Handbuch zur Akteur-Netzwerk-Theorie*, Bielefeld 2006, pp. 369–398, here p. 381: 'The sole essence of a project or the claim to knowledge resides in its entire existence. This existentialism (extended to things!) fills the distinction between rhetorical [...] and substantial questions with a precise content.'

^{xxxi} For a critical perspective on this, cf. Jochen Venus, *Referenzlose Simulation? Argumentationsstrukturen postmoderner Medientheorie am Beispiel von Jean Baudrillard*, Würzburg 1997.

^{xxxii} In a short essay inspired by Karl Marx, Robert Kurz argues precisely in this direction, *Politische Ökonomie der Simulation. Die Realität des Scheins und der Schein der Realität am Ende der Moderne*, <http://www.exit-online.org/link.php?tabelle=autoren&posnr=121>, 05.03.2008.

^{xxxiii} Cf. Peter Galison, 'Abbild und Logik. Zur apparativen Kultur der Teilchenphysik', in: Schröter/Böhnke: *Analog/Digital*, pp. 355–372 on the parallel application and ultimate combination of analogue and digital techniques in particle physics.